The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

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Stabilizing Steel Prices

ELBERT H. GARY, whose death is noted elsewhere in this magazine, was always a strong advocate of a stable sales policy. When he was drafted by John W. Gates to serve as a legal aid in the formation of the Consolidated Steel and Wire Company, he found the industry in a chaotic state with no established sales policy other than the destructive one of contracts "at any price." It was apparent that nothing but turmoil could be expected if such a condition was allowed to prevail, accordingly, he made an appeal for united action against the evil. The officials of the various companies to whom he appealed were eager to adopt a stable policy, provided the action was concerted; thus Gary was largely instrumental in bringing to a termination a condition which was harmful not only to the steel industry, but to purchasers as well. Should Judge Gary have accomplished nothing more than the riddance of this evil, his name would go down in history as one of the greatest benefactors of the industry.

Judge Gary's efforts were directed to the curbing of improper methods within the industry, but there are at times other features over which those engaged in the selling of steel have no jurisdiction. One of these features, which frequently results in unstable conditions, is the publishing of erroneous information by persons or institutions not conversant with the subject on which they write.

How absurd such reports may be is well illustrated in the statement, recently made public, that through the production of sheets on a continuous mill a saving of $28.00 a ton is obtained. The statement, of course, came from an unauthorized source. Inasmuch as 14 gauge sheets are today selling at $47.00 a ton, and the metal cost alone is about $35.00, the absurdity of the assertion is evident.

Unfortunately it is impossible to prevent such occurrences as the one just mentioned, but those directing the sale of steel products should strive to prevent unfair price competition, and thus stabilize the industry.

The Duplex Process Employed in India*

A Very Instructive Recital of the Procedure in Making Steel by a Process Possessing Much Metallurgical Interest —American Practice Followed

By B. YANESKE

PART I

THE duplex process described in this paper is a combination of the Bessemer and open-hearth methods of steel manufacture, and consists of desiliconizing, and partly or almost completely decarburizing, molten pig iron from the blast-furnace in an acid-lined Bessemer converter, and subsequently dephosphorizing the metal in the basic open-hearth furnace. This process is practiced successfully in India by The Tata Iron & Steel Company under difficult climatic conditions with more than 99 per cent of native labor, and the present paper consists of a description of the methods adopted by this company at their works at Jamshedpur.

Although the duplex process originated in Europe and has been practiced in Great Britain and on the Continent, it has never been developed in Europe to the degree it has in America, where it is successfully worked on a very large scale at several of the largest steel works. To some extent the American practice is followed at The Tata Company's works in India, the duplex plant of this company being very similar in design to that of the Indiana Steel Company at Gary, U. S. A.

Jamshedpur was chosen as the site of the works of The Tata Company on account of its central position with regard to the raw materials required for the manufacture of iron and steel, and also its proximity to the junction of two rivers, the Khorkai joining the Subarnarekha about 2½ miles from the town, from which latter river the water supply for the works and town is obtained. The town is situated in the Singhbhum district of the Province of Bihar and Orissa, and is 2½ miles north of the wayside station of Tatanagar, on the main line of the Bengal-Nagpur Railway. Coal is found to the north, iron ore to the south, dolomite and limestone to the west, while the Port of Calcutta, about 150 miles eastward, renders convenient the import and export of materials.

Description of the Duplex Plant

Blast Furnaces—Dealing first with the blast-furnaces, there are five blast-furnaces in all, A and B furnaces being the original units. E furnace was originally erected in Batelle, Ala., and was dismantled, shipped to India, and re-erected at Jamshedpur in line with A and B furnaces, with the same size of hearth and bosh. C and D furnaces are more recent additions, and were blown in in December 1922 and January 1923 respectively, being designed on most modern lines.

Hot Metal Mixer—The pig-iron mixer at the duplex plant was designed to hold 1,300 tons of molten metal. It is of the non-active type, and is heated either with coke-oven gas or coal-tar, burners being placed at the pouring spout and through a port at each end of the vessel.

Bessemer Converters—There are two converters, acid-lined, each of 25 tons capacity, into which the hot metal from the mixer is poured.

Duplex Open-Hearth Furnaces—The installation consists of two tilting open-hearth furnaces, one of 200 tons and one of 250 tons capacity. They are of large proportions, the dimensions of the hearths being 16 ft. x 42 ft. for A, the 200-ton furnace, and 16 ft. x 50 ft. for B, the 250-ton furnace. The overall lengths of both furnaces are the same (92 ft.), the extra 8 ft. in the length of B furnace hearth being taken from the length of the port blocks. The overall width of the furnaces is 22 ft.

The furnace bottoms consist of four courses of magnesite bricks laid upon one firebrick course. Austrian burnt magnesite mixed with basic slag is spread over the magnesite bricks in thin layers, and heated until fritted. Magnesite bricks are also used for the furnace walls and ends, while the roofs are built of locally manufactured silica bricks. The furnaces are provided with slag pockets. The regenerator chambers are 30 ft. in length and 21 ft. 3 in. in height (from floor to roof), the gas chambers being 8 ft. 9 in. wide and the air chambers 13 ft. 3 in. in wide. The regenerators are checkered with 9 in. x 4½ in. x 3 in. firebricks arranged to form a series of 6 in. square flues, silica bricks being used for the last eight courses; the total height of the built-up checker bricks is 16 ft. above floor level, or 11 ft. 4½ in. above the top of the bearer bricks.

The furnaces are equipped with Blaw-Knox water-cooled doors, frames, ports, charging side walls, "monkeys," gas and air reversing valves, and also water-cooled joint castings (chills) fitted between the tilting portion of the furnace and the stationary port blocks. Five doors are provided on the charging side, but only three of these (Nos. 2 to 4) are used for charging purposes.

Pig Iron—The most satisfactory composition of the pig iron to be employed for the duplex process is from 0.90 to 1.20 per cent silicon with about 0.70 to 0.80 per cent manganese, and the sulphur should not exceed 0.045 per cent. This composition, therefore, is aimed at in the hot metal mixer, and after taking all D blast-furnace metal and the available C furnace metal, both of which are usually unsaleable, the metal still required for the duplex open-hearth furnaces is taken from one of A, B, or E blast-furnaces, according to whichever metal is more suitable at the time for maintaining the metal in the 1,300-ton mixer, as nearly as possible at the above composition. The following is an average analysis of metal from the 1,300-ton hot metal mixer during one month's working: carbon 3.95, manganese 0.77, phosphorus 0.344, sulphur 0.034, and silicon 1.07 per cent.

Ferro-Manganese and Spiegel—These steelmaking alloys are manufactured from Indian manganese ore by the Tata Company in one of the blast-furnaces. The average analyses of the grades of ferro-manganese produced are as follows:

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*Paper delivered before the Iron and Steel Institute of Britain, May 6, 1927.

	Carbon %	Manganese %	Phosphorus %	Sulphur %	Silicon %
High phosphorus Fe-Mn	5.95	66.0	1.75	0.022	1.51
Low phosphorus Fe-Mn	5.90	73.5	0.55	0.025	2.35

Any low-grade ferro-manganese falling below 40 per cent manganese which is made in the blast furnace when changing from pig iron to ferro-manganese manufacture, and vice versa, is classed as a spiegel, and is graded into classes according to its manganese content. An average composition of spiegel produced during one year is as follows: carbon 5.05, manganese 22.75, phosphorus 0.60, sulphur 0.020, and silicon 1.75 per cent.

Spiegel is, therefore, not purposely manufactured, and is only produced in small amounts and occasionally added to the open-hearth furnace bath in place of its equivalent of ferro-manganese in order to use up the stock. The amount of ferro-manganese consumed varies, of course, for different grades of steel, the average consumption per ton of steel ingots produced being as follows:

For rail steel (carbon, 0.55 to 0.65; manganese, 0.65 to 0.85), 3.25 lbs.; for structural steel (T. F. Grade) (carbon, 0.22 to 0.26; manganese, 0.50 to 0.70), 3.0 lbs.; and for tin bar steel (carbon, 0.10 to 0.14; manganese, 0.40 to 0.60), 2.0 lbs.; and the average residual bath manganese, 0.10 per cent.

Ferro-Silicon—This alloy is imported and is of a very high grade, averaging 78.35 per cent silicon and 19.2 per cent iron. It is added to the ladle for various steels, the average consumption per ton of steel ingots produced being 0.75 lb. for rail steel, 1.68 for structural steel, and 3.36 lbs. for tin bar steel.

Ferro-Phosphorus—This alloy is also imported, and has been occasionally added in the ladle for increasing the percentage of phosphorus in the steel for sheet bar and tin bar when required, but now the high-phosphorus ferro-manganese previously referred to is used instead. An average analysis of ferro-phosphorus is as follows: carbon 0.70, manganese 3.97, phosphorus 25.08, sulphur 0.20, silicon 7.54, and iron 62.40 per cent.

Aluminium—This is imported in both notched-bar and shot form, and is 99 per cent pure. The average amount consumed per ton of steel ingots is 2 oz. for rail steel, 3½ oz. for structural steel, and 4½ oz. for tin bar steel.

The Working of the Duplex Process

Blast-Furnaces to Hot Metal Mixer—The metal from the blast furnaces are tapped into 60-ton ladles and poured into the hot metal mixer through the pouring-in spout. The distance from the furnaces to the mixer is about ¾ mile.

A sample for analysis is, of course, taken from every cast of pig iron from each blast-furnace; average analyses have been given previously in the paper.

Hot Metal Mixer to Bessemer Converters—Although the original capacity of the hot metal mixer was 1,300 tons, its maximum capacity is now only about 800 tons, owing to the thickness of the magnesite lining of the bottom having been considerably increased since the mixer was first built. It is now usually worked with a maximum charge of about 700 tons, which is quite sufficient for the requirements of the duplex plant.

As the duplex open-hearth furnaces do not usually require metal at each week-end from about 5 P. M. on Saturday to about 6 A. M. on Sunday, all the metal cast between these hours from D blast furnace (or the furnace making pig iron solely for the duplex plant when D furnace is blown out for repairs), amounting to about 375 tons, has to be stored in the duplex mixer, and to allow for this the contents of the mixer are reduced to about 250 to 300 tons on Saturday mornings by not taking metal from A, B, or E blast furnaces, which metal is cast into pigs in the sand-beds or in the pig-casting machine. In the same way the 300-ton hot metal mixer for the stationary open-hearth furnaces stores metal from C blast furnace, so that only saleable pig iron is cast.

The average temperature at which the molten blast-furnace metal enters the mixer is about 1,350 deg. C., and it is kept hot by means of coal-tar and coke-oven gas burners. These are directed on to the metal through the pouring spout, and through a port at each end of the mixer. When hot metal is required for the converters the mixer is tilted, and approximately 22 tons of metal are poured into a 40-ton ladle. It is important that the metal poured out of the mixer be not too hot, especially when the silicon content is high. Otherwise, too high a temperature of the Bessemer-blown metal will be attained, with the result that difficulty in the elimination of phosphorus in the basic open-hearth may be experienced, as explained later in the paper. The temperature of the mixer metal transferred to the converters should, therefore, be from 1,275 to 1,300 deg. C. and should not exceed the latter temperature.

The loss of iron during mixing averages about ½ per cent, so that the average yield from blast-furnaces to converters is about 98½ per cent. Samples of mixer metal for analysis are taken every three or four hours during the pouring of the metal into the converter transfer ladle.

Bessemer Converters to Open-Hearth Tilting Furnaces—If the initial temperature of the mixer metal is not too high, the greater portion of the silicon and manganese of the metal is oxidized during the early period of the blow, and the oxides of these elements unite, with some oxide of iron simultaneously produced, to form a double silicate of iron and manganese slag. It is generally admitted that the oxidation of the elements is an indirect reaction, and that the air in contact with the iron forms magnetic oxide of iron (Fe_3O_4), which is then decomposed by the silicon, manganese, and carbon. Under normal conditions of working the carbon is not appreciably attacked until a considerable proportion of the silicon has been removed, such proportions as are oxidized passing away mostly as carbon dioxide, thus: $Fe_3O_4 + 2C = 3Fe + 2CO_2$.

Instead of blowing all heats down until the carbon, silicon, and manganese are almost completely removed from the metal as in the ordinary acid Bessemer process, the carbon is caught by stopping the blow at an early stage of the boil whenever a high-carbon blow or "kicker" is required for the duplex open-hearth furnaces. These "kickers" vary in carbon according to the grade of steel to be produced in the basic open-hearth. When soft blows are required, the blow is continued until the carbon, silicon, and manganese are almost completely removed from the metal. The metal is then teemed into a 40 or 60-ton ladle, a sample for analysis being taken while pouring. In Table I the percentage of carbon for various blows together with the residual silicon and manganese and the average duration of the blows are shown.

TABLE I
Composition of Bessemer-Blown Metal Required for Various Grades of Basic Open-Hearth Steel.

Carbon required at end of blow Per cent	Average Residual Silicon Per cent	Average Residual Manganese Per cent	Average Duration of blow Min.	Designation of blow and grade of basic open-hearth steel for which blow is required
2.50–2.75	0.20	0.25	6	Final "double-kicker" for rail steel (0.55 to 0.65 per cent C)
1.50–1.75	0.07	0.13	9	Final "single-kicker" for structural steel (0.22 to 0.26 per cent C)
1.00	0.04	0.10	11½	Preliminary "single-kicker" for rail steel (0.55 to 0.65 per cent C.) Final "single-kicker" for sheet bar and tin bar steel (0.10 to 0.14 per cent C)
0.10	0.01	0.07	14½	Soft blows for all steels

The curves in Fig. 1, which are plotted from analysis taken over a period of six months, illustrate the rate of oxidation of the carbon, silicon, and manganese during the blow under normal conditions, that is, with an average air-blast of 21 lbs. per sq. in. in the converter wind-box, and an average weight of 22 tons of mixer metal of the composition previously stated—viz., carbon 3.95, manganese 0.77, phosphorus 0.344, sulphur 0.034, and silicon 1.07 per cent.

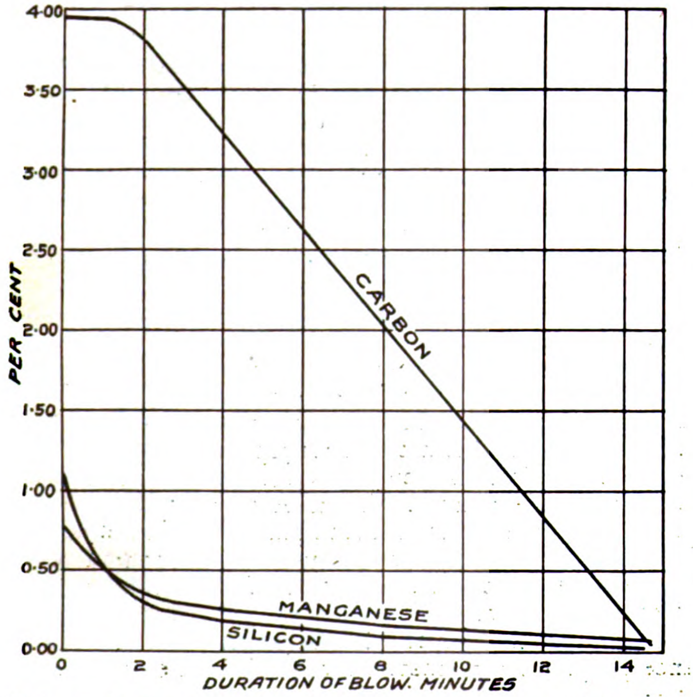

FIG. 1—Curves showing the average rate of oxidation of carbon, silicon, and manganese in the Bessemer converter during blowing.

With regard to the sulphur and phosphorus content of the metal, the former element is not removed at all during the blow, but is rather inclined to increase owing to the original weight of sulphur being present in a reduced weight of metal after the blow, and whereas the average percentage of sulphur in the mixer metal is 0.034 per cent this is increased to 0.037 per cent in the blown metal. On the other hand, phosphorus is removed to a small extent, possibly by volatilization, as its removal by oxidation is prevented by the large amount of silica in the converter lining in contact with the metal. The only form in which phosphorus could be oxidized would be as phosphate of iron, but this is decomposed by silica, phosphorus pentoxide being liberated and decomposed by the iron with the formation of iron phosphide and oxide. The average phosphorus content of a large number of heats of blown metal was 0.283 per cent, while the average phosphorus content of the mixer metal before blowing during the same period was 0.344 per cent, so that there was approximately 18 per cent less phosphorus in the metal after the blow. It will be observed from the average composition of converter ladle slag given below that 0.048 per cent phosphorus pentoxide is contained in the slag, but this amount is insufficient to account for all the phosphorus removed from the metal.

A certain amount of manganese, silicon, and iron, especially the latter, which is, of course, present in great excess, is also volatilized, and accounts for some of the metal lost during the blow.

The yield of blown metal from mixer metal from actual weighings is 91½ per cent, the 8½ per cent loss being due to oxidation, volatilization, and ejection of metal during the blow, and to occasional skulls formed in the converters and ladles. The total yield, therefore, from the blast furnaces to the duplex open-hearth furnaces—that is, from the blast furnace metal to converter blown metal—is approximately 90 per cent.

An average composition of a considerable number of ladle samples of normal converter slag, which has a dark grey fracture, is as follows:

Silica	55.15	per cent
Alumina	5.25	"
Ferric oxide	4.40	"
Ferrous oxide	12.41	"
Manganous oxide	19.50	"
Lime	1.35	"
Magnesia	0.39	"
Titanium oxide	1.18	"
Phosphorus pentoxide	0.048	"
Sulphur	0.053	"

Calculations based on the above slag analysis show that a certain amount of manganese is lost by volatilization and ejection of metal during the blow. In a certain case, the approximate weight of slag, determined from the silicon content of the metal and the silica contained in the slag, was found to be 1971 lbs. The slag assayed 19.5 per cent manganous oxide, which corresponded to 297.7 lbs. of manganese. The metal, weighing 49,280 lbs., lost, however, 0.68 per cent manganese by oxidation, representing 335.1 lbs. of that metal. The difference, 37.4 lbs., or 0.075 per cent of the original weight of mixer metal, then, represented manganese lost by volatilization, etc.

From the slag analysis can also be calculated the amount of iron, which is either volatilized or is returned to the metal after first being oxidized early in the blow and subsequently reduced by the carbon during the boil. In the case quoted above, the total iron in the slag was calculated to be 250.9 lbs. The amount of iron, however, required to form ferrous silicate (Fe_2SiO_4) with the silicon originally in the mixer metal was 844.6 lbs. The difference, then, was 593.7 lbs., or 1.2 per cent of the original weight of mixer metal. This disparity might to a certain extent be due to volatilization of iron, but most of it is probably accounted for by the reduction of some of the magnetic oxide of iron, formed in the early part of the blow, by the carbon removed during the boil, according to the equation:

$$Fe_3O_4 + 4C = 3Fe + 4CO.$$

This seems to be proved by the representative analyses given in Table II of converter slag samples taken at the end of the blow for the different carbons specified in Table I.

TABLE II

Analyses of Converter Slag Samples at Different Stages of the Blow.

Composition of metal at end of blow. Per cent			Composition of slag at end of blow Per cent				
Carbon	Silicon	Manganese	SiO_2	Al_2O_3	Fe_2O_3	FeO	MnO
2.50 – 2.75	0.15	0.22	50.94	4.78	5.18	20.16	17.47
1.50 – 1.75	0.07	0.13	55.88	5.41	4.23	14.37	18.40
1.00	0.04	0.10	58.23	5.92	3.95	8.81	19.95
0.10	0.01	0.06	54.86	5.18	4.38	12.02	19.83

It is generally agreed that the volatilization of silicon, manganese, and iron takes place during the blow, for the oxides of these elements have been found in the fume produced. The analysis of fume given by Schöffel* is as follows:

FeO %	MnO %	SiO_2 %
16.29	48.23	34.86

Therefore if silicon is volatilized, the weight of slag produced would be somewhat less than the 1,971 lbs. obtained by the preceding calculations in which any loss of silicon from the metal which might have occurred owing to voltaliziation has been ignored; but, on the other hand, the weight of slag may be more than that calculated, owing to the wear of the converter lining and erosion of the bottom.

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*Vide p. 79, 'The Metallurgy of Steel," by F. W. Harbord.

(To be continued)

Camera Detects Defects in Steel

Many of the defects which creep unsuspectingly into the manufacture and construction of steel plates and other steel objects may be corrected in the future through the use of a new camera invented by C. Francis Jenkins, Washington, D. C., scientist.

The invention which may prove of inestimable value to the steel industry is called "the Jenkins Chronoteine Camera for high speed motion studies." With this comera it is possible to study the action of machinery, the condition of steel objects during the early stages of their construction and also enables the manufacturer to perfect his product before shipment. The camera helps to detect possible faults and discloses the need for refinements in inventions passing through their experimental stages. It makes movies photographed at a rate of 3,200 exposures per second, or a length of 200 ft. of film per second.

Projection of these pictures at normal rate, 16 per second, makes the action 200 times slower than the original movement and 20 times slower than the slow motion films frequently shown in picture theatres.

In the production of steel, according to experts, it often is difficult to detect the causes of faulty manufacture. Defects sometimes arise from minor faults in the machinery which cannot be noticed by the unaided eye. In studying the movement of machinery and its affect upon the formation of steel objects, experts have had to resort to the stroboscope, which does not always prove adequate. With the chronoteine camera the same steel experts could have a slow motion picture record of the early stages of steel construction and would be able to detect, the inventor believes, the causes for the minor defects in the finished product.

The ordnance departments of both the United States Army and Navy believe the use of the camera invaluable in testing out the resisting power of steel plates for battleships. Through the use of the camera, it is possible to obtain a positive record of the minute reactions of the plate to the impact of the shells.

American Telephone and Telegraph Company Installing Additional Cable Lines

When the 1927 construction program of the Long Lines Department, American Telephone and Telegraph Company, was announced, it was noted that long distance cable work was by far the largest item on the list. The more than one thousand miles of cable and related equipment to be placed this year, on which construction work is well under way, call for an expenditure of nearly half of the $34,000,000 total involved in the year's program.

Several of the outstanding cable jobs for the current year are the Albany, N. Y.-Cleveland route, Chicago-Terre Haute route, Kalamazoo-Grand Rapids and Washington, D. C.-Richmond, Va., routes. Work is well under way on the Pittsburgh-Terre Haute cable which will provide another all cable route from Pittsburgh to Chicago. In addition to this current work plans now being made call for cable routes from Wyanet, Ill., to Omaha, and from Richmond, Va., to Atlanta.

On a number of the principal routes more than one cable is already in service and additional cables on these same routes are either being installed or are planned for installation in the near future. Additional cable has been installed this year between New Rochelle, N. Y. and Stamford, Bridgeport and New Haven, Conn. Work is now in progress for additional cables from Newburg, N. Y., to Albany; Harrisburg, Pa., to Ligonier, and Philadelphia to Wilmington. Work will also be started this year on a second cable between New York and Reading, Pa., and between Toledo and Detroit.

For 1928 and several following years the long distance people plan to install about 1,350 miles of cable a year.

While cable routes are being steadily extended between the more populous centers, open wire construction continues to play an important part in the country's communication system. New pole lines are still being built. Among these are lines from Portland, Me. to Montreal, Canada; Nacogdoches, Texas, to Shreveport, La., completing a route between Shreveport and Houston; Trinidad, Col., to Armarillo, Texas, and many others.

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ELBERT H. GARY

ON the morning of August 15, announcement was made of the death of Elbert H. Gary, chairman of the board of the United States Steel Corporation. As only Mr. Gary's closest associates were aware of the seriousness of his ailment, the news came as a distinct surprise to the public at large. Death, which was due to myocarditis, an inflammation of the tissues of the heart, came at 3:40 A. M.

Very few men have lived as did Judge Gary. Although 81 years of age he was mentally keen as attested by the fact that on the day of his death he was head of the greatest steel corporation in the world. This corporation he dominated since its formation in April, 1901. Surely few men have rendered as great service to the steel industry, in its entirety, as did Mr. Gary. Although he served with fidelity, the organization of which he was head, nevertheless by his policies and broad mindedness he stabilized the industry and was largely instrumental in eliminating the destructive competition which prevailed for many years.

Mr. Gary possessed characteristics that stood out in bold relief, and that qualified him to be looked upon as an executive of exceptional ability. His experience as a lawyer and a judge enabled him to consider, without prejudice, the many problems constantly arising and calling for action. This same experience was valuable in shaping the policies of the United States Steel Corporation at the time that corporation was formed. In 1891 Mr. Gary effected the organization of the Consolidated Steel & Wire Company of Illinois, and in later years was legal advisor and president of the Federal Steel Company. He thus became well acquainted with corporation management before he was called upon to aid in merging the various companies that are now subsidiaries of the Steel Corporation.

Probably one of the most outstanding characteristics of Judge Gary was his sense of fairness. This was well illustrated at the time the government requested that all financial matters in connection with the formation of the trust be submitted for inspection. There was no hesitancy in complying with this request on the part of Mr. Gary. This same spirit of fairness was also evinced in his dealings with competing companies with whom he always encouraged co-operation in matters of mutual concern.

In his relation to labor he was always in sympathy with any just movements which might better conditions. Thus he instituted the eight-hour day in the plants under his control, as far as such a change was practical. Although he was opposed to unionized labor he would listen to any appeal from employees who had a grievance to submit. The safety first and welfare movement had his sincere support.

No man could maintain the position held by Mr. Gary unless he was courageous and firm in his convictions. Where a decision was required on any subject, there was no equivocation, neither was there any hesitancy.

Not only was Judge Gary's ability as an organizer manifest in the skill shown in the formation of the United States Steel Corporation, but in molding an efficient operating force in his own companies he was equally proficient. In fact the success of this corporation has, in a considerable measure, been due to the policies of organization promulgated by Mr. Gary. In any appraisal of his merits there is no question, but that much value will be placed on this ability to secure co-operation.

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Motor Drives for Elevators and Conveyors

Before Advising the Type of Motors to Install the Operating Characteristics of the Driven Equipment Are Enumerated. Needful Accessories Listed

By GORDON FOX*

PART II

THE power required by conveying and elevating machinery is dependent, in part, upon the type of equipment primarily because of differences in efficiency. For this reason the foregoing paragraphs have included discussion and formulae for the determination of load for several common conveyor types.

From the power standpoint, the various kinds of conveying machinery have many common attributes. In all cases friction load comprises an important or major part of the entire load. For horizontal conveying, the load is entirely frictional. This component of load has a constant torque characteristic. Where material is elevated the work component has a constant torque characteristic also. Both components are affected by the degree of loading of the conveyor.

Because of the many bearing surfaces and the predominating frictional component, the power requirement of conveying and elevating machinery is subject to variation and is not susceptible to accurate predetermination. Many factors, such as rusted joints, abrasive materials in the joints, cold and congealed lubricants, overloading and clogging can increase the power consumption materially. For these reasons it is generally desirable to select motors of liberal size. This is particularly the case with these conveyors which are subject to the most variable conditions. Fairly liberal motoring is justifiable even when induction motors are used, notwithstanding the power-factor objection. The very considerable frictional load component associated with the operation of this class of machinery generally prevents the operation of motors at extremely light loads, even though they may be somewhat oversize. Inadequate motoring is never justifiable even for power-factor considerations.

Because it is so frequently impossible to predetermine the load requirement of conveying machinery, it is particularly desirable that measurements or load charts be obtained after installations are in service, care being exercised to secure data representative of most severe conditions as well as prevailing service. With definite load data available it is then permissible to motor closely and inadvisable to continue in regular operation induction motors which are grossly oversize.

Starting Torque

The great majority of conveyors are continuous running. The operation is almost universally unidirectional although in some instances the ability to back-off is desired. Starting is rather infrequent. The operators are ordinarily of the common labor classification.

Although elevators and conveyors are commonly started light, the motor supplied must be capable of starting the conveyor when full of material since an interruption of power or other trouble may cause the conveyor to stop while full. Sometimes the material, such as clay, tends to set while standing, so that exceptionally high starting torque is required. Static friction, particularly in chain type elevators and conveyors may greatly exceed running friction. Cold weather may greatly increase the torque required to start a conveyor. Many things may increase the friction above normal. For these reasons a motor for conveyor drive must have liberal starting torque capacity.

The Squirrel Cage Induction Motor

Because of the constant-speed continuous-running service, a.c. motors are well suited for most conveyor drives. A wide range of sizes are involved, from 5 to 500 hp. Because of its simplicity, good general performance, low cost and standard nature, the squirrel cage induction motor has been widely used for conveyor service. While the running characteristics of this motor are admirable, it is apt to be deficient in starting performance. Even with full voltage applied, the standard squirrel cage motor will develop only a little more than its full-load torque. The static torque

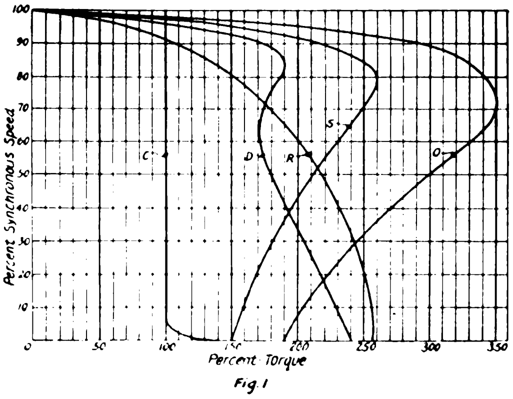

Fig. 1

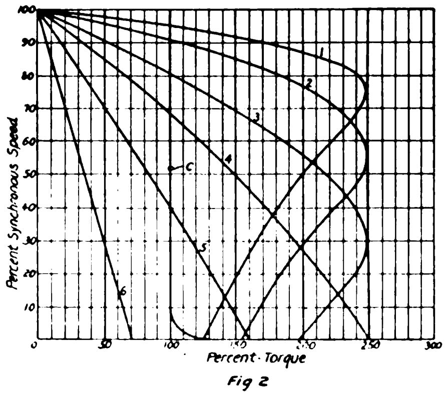

Fig. 2

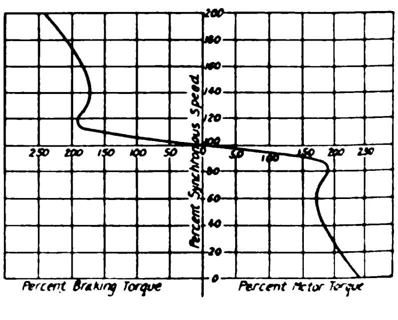

Fig. 3

FIG. 1—Curves showing speed-torque characteristic of a conveyor and the several types of squirrel-cage induction motor which may be used for driving. FIG. 2—Conveyor characteristic and curves of wound-rotor induction motor with various values of secondary control resistance. FIG. 3—Speed-torque curves of double squirrel-cage motor used both for driving and retarding conveyor service.

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of a conveyor is generally greater than its running torque. Curve C in Fig. 1 represents the torque characteristic of a conveyor which requires 100 per cent torque when running fully loaded but which has a starting torque of about 133 per cent of full-load torque if started while full. Curve S, Fig. 1, shows the speed-torque curve of a standard squirrel cage motor having sufficient running capacity to drive this conveyor. It will be noted that, even with full voltage impressed, this motor develops but 125 per cent of full-load torque and would therefore be incapable of starting this conveyor fully loaded.

If an oversize standard squirrel-cage motor be employed, the speed-torque curve O, Fig. 1 is obtained. If full voltage be applied this motor has sufficient starting torque to start the conveyor under load. There is considerable argument favoring an oversize squirrel cage motor inasmuch as a marginal capacity is desirable to meet the exceptional conditions of excess friction, extra heavy or wet material, etc. However, since these exceptional conditions may also apply to increase the starting load, even an oversize motor does not afford positive assurance of starting under all conditions.

The Wound-Rotor Induction Motor

The wound-rotor induction motor is excellently suited in electrical performance characteristics for conveyor drives in general. In running performance it is almost the equal of the standard squirrel cage motor. In starting it can develop any torque up to its maximum torque at standstill, thus affording a definite and safe margin in this respect. The starting torque can be gradually applied by utilizing sufficient secondary resistance. The relations between conveyor torque and motor torque capacity on the several points of the secondary controller are shown in Fig. 2 in which curve C is the conveyor characteristic while curves 1, 2, 3, 4, 5, 6 are motor characteristics on the several controller points.

While the wound-rotor induction motor is well suited for conveyor drives its greater complexity and its higher first cost are deterrents to its general adoption, particularly for the smaller sizes. For the larger sizes the lower starting-current inrush may be an additional consideration favoring the selection of the wound rotor induction motor.

High-Resistance Rotor

In order to secure sufficient starting torque a squirrel-cage induction motor having a high-resistance cage winding in the rotor may be used. The speed-torque characteristic of such a motor is shown in Fig. 1, curve R. While this motor has ample starting capacity, the greater slip while running is attended with resistance losses which materially affect the efficiency of the drive and which are of consequence also in the matter of heat dissipation with continuous running. For these reasons this type of motor has not been generally adopted for conveyor drives. For conveyors which are operated only intermittently, this type of motor should prove quite satisfactory.

Double-Cage Windings

The squirrel-cage induction motor with double cage winding is pre-eminently suited for many conveyor drives. The torque of a motor of this type is shown by curve D, Fig. 1. This type of motor will develop sufficient torque at stand-still to start the conveyor under almost any adverse conditions. It is permissible that full voltage be applied in starting, without causing undue line disturbance, although it may be desirable to restrict the voltage in order to cushion the starting impulse. This type of motor is almost as simple as the standard squirrel cage motor. Its efficiency and its power-factor are slightly lower, with equal loading, but the double-cage motor may be superior, in these respects, to an oversize standard single squirrel-cage motor normally operating with a lesser degree of loading. The control for a double-cage motor is the same as that required for a single-cage motor and is simpler than that required by the wound-rotor induction motor.

Direct-current motors may be used for driving conveyors and bucket elevators where such current alone is available. The compound-wound motor is the preferable type for constant-speed service, affording good starting torque with moderate current input, yet assuring a fairly definite and constant speed. The series wound motor would be suitable for conveyor drives, where the motor may drive through positive chain or gear, were it not for the fact that the indefinite and variable loading renders the operating speed rather uncertain. The shunt-wound motor can be used for conveyor drives but it is less capable in starting performance. The use of liberal motor sizes is quite desirable when d.c. motors are used as they are more vulnerable to overloading than a.c. motors and there is little objection other than the greater investment involved.

Adjustable Speed

Where adjustable speed operation is desired, several alternatives are available. With d.c. the solution is easy, through use of the adjustable speed motor. Where a.c. is to be used the multispeed motor will give two or more speeds which may suffice. If so, this is a rational selection particularly in view of the fact that the multispeed motor is essentially a constant torque machine. An alternative to the multispeed motor for two-speed drives is the use of two motors, one for each speed, the motor for the higher speed having the higher horsepower. Where a moderate range of speeds is required the wound-rotor induction motor with secondary control can be applied. The principal objection to this method is the considerable loss of power incident to speed reduction and the somewhat varying speeds occurring at the lower portion of the range. Where wide speed ranges and fairly definite and constant speeds are desired, the use of variable speed transmissions, such as the Reeves, has been successful. For very slow speeds, such as for assembling conveyors, the oilgear type of variable speed transmission has been used effectively.

Control Selection

The control requirements of conveyors are relatively simple. Ordinarily uni-directional operation will suffice but sometimes an emergency reverse or back-off provision is desirable. Partly because of the unskilled character of the probable operators and also because of the abuse of motors and conveyors possible with manual control, the rather general adoption of magnetic control is suggested. The principal essentials of a control for a conveyor are the avoidance of too sudden shock in starting and the definite functioning of the control to put the motor on the line.

If a standard squirrel-cage motor be used it will likely be necessary to apply full voltage to start the conveyor. If a squirrel-cage motor be used having a high resistance rotor or a double-cage winding an excess of torque will be available if full voltage is applied initially. Here reduced voltage starting is advisable. Any of the usual methods may be employed. Primary resistance or primary impedance starters have, in the writer's opinion, a measure of advantage in that they permit of a minimum initial voltage which gradually increases as the motor accelerates. This compensates the tendency for the developed motor torque to fall off as the motor accelerates, as shown in curve B, Fig. 1. It is possible to bring the conveyor more nearly to speed on reduced voltage, minimizing the current peak as well as the mechanical shock incident to the transfer to full voltage.

In any event, where magnetic control is used, time-element acceleration, or its equivalent, should be employed. Current-limit acceleration in any form is undesirable, as a cold day or any unusual condition may result in failure to cut out the starting means, leading to a burned-out controller. With time-element control minimum starting voltage may be used to insure smooth starting under normal conditions. When extra load is involved the starter will apply additional voltage and definitely start the motor or else it will trip the overload relays.

Overload Protection

As conveyor motors are generally located more or less out of sight and as the load is subject to variation, reliable overload protection is even more necessary than for motors under regular observation. Instantaneous trip circuit breakers or overload relays are of advantage as a protection both to the motor and to the conveyor itself in case foreign material or other mishap causes a jam. Inverse-time or thermal relays may well be used to protect the motor from gradually applied overloads but they are not rapid enough in action to be used alone.

When a conveyor feeds a process machine or feeds another conveyor it is usually desirable that the feeding conveyor stop when the machine or fed conveyor stops, in order to prevent a piling up of material. Interlocking is commonly practiced by opening a pilot circuit or trip circuit of the control of the feeding conveyor when the fed machine is shut down. The machines must then be started again in proper sequence.

Conveyors by nature cover considerable space. It is often desirable to start or more particularly to stop the conveyor from a plurality of stations along its run. Magnetic starters may be easily arranged for both starting and stopping from several points. The remote stop feature may be obtained with most any control through use of push buttons interrupting a pilot or no voltage trip circuit of the starter.

Retarding Conveyors

In some cases conveyors, particularly belt conveyors, are used to convey material down an incline. The weight of the descending mass may be sufficient to overcome the friction of the conveyor and to require a retarding effort on the part of the motor. On the other hand, the empty or partially loaded conveyor may require a positive driving effort. For this class of service the shunt-wound d.c. motor or the induction motor with a flat speed characteristic is desirable. Such a motor will operate as an induction generator in the event of overhauling load with relatively small speed increase, as shown by the curve in Fig. 3. It is not desirable to use a squirrel-cage motor with high resistance rotor nor to use a wound-rotor motor with secondary resistance in circuit. These motors have a decidedly sloping speed characteristic and will require that the speed increase quite materially before retarding torque is developed. The wound-rotor motor is not objectionable for this service so long as the secondary resistance is cut out. It cannot be used for speed control of this type of conveyor.

If an elevating or inclined conveyor is stopped while hoisting a load the weight of the material may tend to drive the conveyor backward. If this is objectionable it may be overcome by use of some form of ratchet or stop applied to the conveyor drive or electric brakes may be used.

In the case of the retarding conveyor, the motor is not able to stop the descending load so that electric brakes may be required.

Motors driving conveyors are of moderate speeds driving through one or more gear reductions or by charm or belt from the motor to the first reduction shaft. Gear reducers are justly popular as an intermediary between motors of moderately high speeds and low speed conveyors. Belt drive has the advantage of relieving the motor from shock and vibration. In general, conveyors do not contribute to cleanliness. The motor should be located where it will be as free as possible from droppings and dust. Total or partial enclosure is frequently desirable.

American Management Association

The metal and machinery industries are prominently represented in a group of 41 leading business executives who have organized an advisory board of the American Management Association, feeling that improved management methods are essential in maintaining present prosperity and that knowledge of such methods should be spread more quickly throughout business.

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Correction

In the August issue of this magazine there appeared a paper entitled "The Centrifugal Casting Process" by John D. Capron. Credit for this paper should have been given The American Iron and Steel Institute, but through error such recognition was not made. The paper was delivered before the meeting held on May 20, 1927.

Selection of Corrosion Resistant Alloys

Causes of Corrosion Are Explained—Elements Which Increase Resistance of Steel Are Silicon, Copper, and Chromium—Non-Ferrous Alloys Effective Under Certain Conditions

By WALTER M. MITCHELL*

IT is not the purpose of this paper to discuss the various theories of corrosion, or to give a catalogue of corrosion resistant alloys; but rather to discuss some of the factors causing corrosion, and the characteristics of the different types of alloys which may be used to combat it. In addition, the precautions to be observed in the selection of such alloys, and the conditions under which they may be successfully used.

The problem of finding materials suitable for the construction of apparatus for the manufacture of products which are by nature corrosive, or where such materials are used, is one of the major difficulties in many industries. No industrial problem can be considered as satisfactorily solved until a suitable material has been found in which the process or the reactions involved may be carried out on a large scale. The importance of this problem has perhaps been overlooked in the past, because in so many operations a suitable material has been easily found; but a glance through the patent literature will show that this is not always the case, and the lack of a suitable material has been a stumbling block in more than one important process. With the advent of the newer synthetic processes for large scale production of various chemical products, the problem has become of greater and greater importance. When we realize that for the synthesis of ammonia, according to the Claude process, containers must be secured which will withstand pressures of 1,000 atmospheres at 1,000 deg. F., and at the same time be immune to the action of hydrogen, the metallurgical difficulties involved may readily be appreciated.

The prevalence of lined equipment in chemical plants, and the use of various coating processes producing a surface which will have certain qualities different from the metal which supports it, specified either by corrosion resistance or appearance, illustrates the same point and may be considered as evidence that no single material has been found entirely satisfactory for the purpose, taking into consideration, of course, the question of cost and chemical and mechanical suitability. This applies not only to chemical industries but to many of the activities of our everyday life as well.

A review of modern practice in combating problems of corrosion indicates several methods of solution:

1—Methods based on the treatment or elimination of the corroding material or liquid.

2—The use of a protective coating either of another metal, or by a substance in the form of a paint or enamel.

3—Electrochemical protection.

4—Replacement of the metal attacked by some other metal which is inherently immune, or whose resistance to attack is greater than that of the metal at present employed.

Considering these methods individually, the most notable application of the first method is in the treatment of waters used in feeding boilers and in the cooling systems of condensers by the use of silicate of soda, soda ash, lime, and other materials. In chemical industries this method is barred, as there are but few instances where products in course of manufacture may have other ingredients added which will reduce the attack on the containers.

The second method has wide usage. The simplest means of protection, by a metallic coating produced by immersion in a bath of molten metal, is utilized in galvanizing, tinning, etc. The process has the advantage of simplicity, but is apt to be wasteful as the coating is by no means uniform in thickness. Further, there is always a fair proportion of sheets or articles on which the coating is imperfect. The article may be coated with a layer of protecting metal by electrolytic action, as is successfully done with nickel, copper, zinc, chromium, cobalt, etc. and there are instances where plated articles are in successful use in chemical plants. A primary advantage is reduced cost, as the application of the protective layer, with the small quantity of metal necessary for coating, may be less than the cost of the identical article made of solid material; but it is also to be remembered that its life may be correspondingly short. Cementation processes, as in sherardizing with zinc, and calorizing with aluminum, are successfully used and find frequent application. Mention might be made also of mechanical coating processes, in which molten metal is sprayed in a fine stream by a blast of air; or, as in the manufacture of copper clad sheets and rods, which are fabricated from a composite ingot made by casting a copper layer around a steel billet.

The practical disadvantage of the metallic coating, no matter how produced, is that it is primarily a substitute introduced because of the lack of a better material and also because of the potential presence of inperfections. When such actually exist, the underlying metal is exposed and an electrical couple set up, and this may lead to increased attack on the more reactive of the two metals, as in the case if iron is covered by a more noble metal, as nickel, copper, tin, etc., where corrosion is actually accelerated.

Protection secured by paints, bituminous mixtures and enamels, is outside the scope of this discussion and hence will not be considered.

The third method has been successfully applied to the protection of condenser tubing, steam boilers and the like. It consists in using a slab, or a piece of metal (usually zinc) less noble than the metal to be protected and electrically in contact with it so that it will act as the anode of a galvanic couple. In this way the attack is concentrated on the slab, which is easily replaced, and the balance of the apparatus which forms the cathode is not attacked.

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The fourth method; namely, replacement of materials of construction by others which are less subject to attack is the most important of the methods for the prevention of corrosion and merits considerable discussion. During recent years there have been many attempts to prepare alloys which are highly resistant to corrosion, but this is not an easy matter. Non-corrodibility, though eminently desirable, must sometimes be sacrificed to other considerations, since properties such as machinability, forgability, and the requisite strength and toughness must always be provided for. However, very considerable success has already been obtained and the future most certainly will reveal still greater triumphs. It is not to be inferred, however, that the discovery of any single alloy of commercial metals which is universally corrosion resistant, or even approximately so, is to be expected; but rather that various alloys will be introduced each capable of withstanding some particular class of corrosive agents and hence suitable for use in certain definite conditions.

Mechanism of Corrosion

In considering metals and alloys from the standpoint of susceptibility to attack, it is necessary to consider briefly the mechanism of corrosion and the conditions which tend to accelerate or retard it. Considered in tthe broadest sense, corrosion is simply the result of the laws of chemical affinity, and is a manifestation of every physical system to dissipate its store of potential energy toward the establishment of a condition of equilibrium. The theory of corrosion which suggests that corrosion is the result of electrochemical action which causes a given material, as a metal, elements which, being chemically more inert, are precipitated out in some form or other. There are two reactions to be considered:

(a) Anodic—The solution of the metal in the solvent as determined by its solution potential, or tendency to dissolve, with the formation of ions.

(b) Cathodic—The displacement of one of the constituents of the solution, either as a precipitated material, or as a gas, and the disposal of the precipitated material by chemical combination or otherwise.

As a simple illustration of the manner in which these reactions take place, we may consider iron immersed in dilute acid. The anodic reaction is the solution of the iron in the solvent with the formation of ferrous ions. The cathodic reaction is the decomposition of the solution with the substitution of iron for hydrogen, which is thus displaced or liberated. The hydrogen so liberated is removed by combination with dissolved oxygen in the solution to form water, or appears as hydrogen gas, either collecting on the surface of the iron to act as an insulating or polarizing film, or even escaping from the solution as a free gas.

Since these reactions take place in sequence, the rate at which corrosion takes place is naturally dependent upon the speed of the second reaction, or upon the available supply of oxygen upon which the disposal of the set free hydrogen depends; and hence, the importance of the presence of oxygen. Obviously, the iron cannot enter the solution faster than the removal of the hydrogen permits its displacing more hydrogen.

What is true of iron and hydrogen, is true of any two metals, since hydrogen is chemically analogous to a metal.

The solution potential or the force tending to drive a metal into solution is a function of its chemcal properties and is in the nature of a constant for each metal if the conditions affecting solution are defined, the lighter and more reactive metals having the higher solution potentials, while the heavier and more "noble" metals the smaller. The solution potential will, however, vary considerably for a given metal, depending upon the nature of the solvent, whether acid or alkaline, the temperature, concentration, the condition of its surface, etc.

Listed in order of normal electrode potentials, the metals appear in series somewhat as follows: Potassium, sodium, barium, strontium, calcium, magnesium, aluminum, manganese, zinc, cadmium, iron, cobalt, nickel, lead, tin, hydrogen, bismuth, copper, antimony, aresnic, mercury, silver, palladium, platinum, silicon, tantalum, tellurium, boron, tungsten, molybdenum, vanadium, and chromium; any metal in the series displacing from solution others which follow it.

The position of certain metals which assume the "passive" state, such as chromium, vanadium, etc., is somewhat anomalous. In the "active" state chromium is usually placed between zinc and iron, but while in the passive condition it should certainly be placed high in the list. The order given above by no means holds in all cases, and there will be decided alterations in the arrangement when different solutions are in contact with the various metals.

While the above discussion explains the primary reactions underlying corrosion of metals in general, the influence of various factors will greatly modify the rate at which it takes place. These factors may be grouped broadly under two heads—internal and external.

Homogeneity—a Factor in Corrosion

Considering internal factors, the most important—barring chemical composition—is the homogeneity of the metal. The presence of constituents in an alloy or metal differing in density, chemical composition, or mechanical condition, is similar in effect to the presence of another metal with different solution potential, and corrosion at once follows, either of the surrounding metal or of the foreign material, depending upon their potential differences. The same is true of foreign inclusions such as sand, slag particles, or of chemical impurities, as oxides, phosphides, sulphides, etc., causing what is technically known as "dirty" metal. Such inclusions are generally of different solution potential and invariably give rise to rapid local attack with resultant pitting. Consequently, unless modified by other influences, the greater the purity of a metal, the greater its inherent resistance to attack. Hence, what is called "Quality;" that is, the effects of all manufacturing variables other than chemical composition is of primary importance from the standpoint of corrosion resistance.

Alloys of all types can be divided very broadly into two main classes: The true alloys; that is, those forming solid solutions in which there are no free constituents; and those not forming solid solutions, in which separate constituents such as eutectics, carbides, intermetallic compounds, etc., appear.

In the case of a pure metal what may be called the "unsatisfied" affinity of its atoms for the atoms of other substances determines the energy with which it will combine with these, displacing some other element with which the stranger atoms have previously been in combination. If the affinity of these atoms can be partially reduced by the atoms of some other metal, as is the case in solid solutions, the resistance to corrosion is greatly increased. If this affinity is still further reduced by the presence of a third metal entering solutions, there is still greater resistance to attack. This is well illustrated by numerous alloys. For instance, pure iron is readily attacked by oxygen even at normal temperatures. If chromium, in reasonable proportions is added, resistance to attack at ordinary temperatures is practically complete and may even extend to moderately elevated temperatures. If a third metal, as nickel or silicon is added, which in proper proportions also enters solution with the iron and chromium, resistance to oxidation is extended to still higher temperatures. Similar characteristics are well known in the case of other combinations and need not be enumerated here.

Obviously, then, the solid solution class of alloys is inherently the better type for resistance to corrosion, not only from the chemical standpoint but the mechanical standpoint as well, since such alloys almost invariably possess the highest physical properties as regards both strength and toughness of any alloy of the series.

In the second class of alloys, which are merely mechanical mixtures of the various constituents, action due to potential differences takes place between the constituents themselves, always at the expense of one of them, so that this type of alloy is not in general desirable for corrosion resisting purposes. Cast metals, unless of the highest purity and alloys in the "as cast" condition are in general far from being homogeneous, and this includes the solid solution forming alloys. Owing to the mechanism of solidification, impurities and alloying metals always segregate, either in the dendrites themselves, or in larger masses, depending upon the character and shape of the casting. In the solid solution type of alloy this segregation will be dispersed by proper annealing, or other heat treatment, so that practically complete homogeneity will eventually be produced. If the alloy is not solid solution forming, annealing will cause coalescence of the various constituents into still larger individual masses, coarsening the structure and increasing tendency to corrosion, beside reducing the strength and toughness.

Mechanical working, such as rolling or forging, which is done hot, breaks up the non-homogeneity of cast structures, compacts the metal, closes up porosities and blow holes and is decidedly beneficial; that is, rolled or forged metal will be less attacked than cast metal of the same chemical composition. Cold working, which is distinctly advantageous as regards strength and hardness, sets up strains, and strained metal because of the unstable atomic arrangement so induced has a higher solution potential than unstrained metal. Hence, tubing, sheets, etc. which have been cold drawn or cold rolled will be more rapidly attacked than similar material, other things being equal, which has been annealed to remove strains. In such cases, mechanical strength must be sacrificed for greater corrosion resistance. Likewise, a machined surface is more readily attacked than a polished surface, as the polishing operation removes the thin skin of strained metal remaining from the action of the cutting tool.

The effect of grain size appears to be uncertain and the results of tests are contrary. In any event, the effect of grain size in itself as increasing the tendency to corrosive attack appears to be small.

Considering the influence of the internal factors as a whole, neglecting for the moment the question of chemical composition which will be discussed in more detail later, the corrosion of ordinary commercial metals is considerably less dependent upon the internal factors than upon those external; i.e., the surroundings of the metal when in use. In other words, manufacturing methods, always assuming reasonable care is used, the internal factors being in this way subsidiary to external conditions.

The principal external factors which affect corrosive attack include the following:

1—The amount of dissolved oxygen in solution reaching the metal surface together with its distribution.

2—The kin of substances, and their concentration, to which the metal is exposed in cases where the effect of oxygen is of minor importance.

3—The formation of protective surface films.

4—Influences which tend to localize corrosive attack and to produce pitting.

5—Temperature.

6—Rate of agitation of solutions.

These factors are closely dependent one on the other, and the degree of one will readily be affected by the influence of some other. Such interdependence accounts for the complexity of the corrosion problem and for the difficulty in tracing through to their ultimate causes definite cases of corrosive attack.

Dissolved Oxygen

Of all the external factors, the quantity of oxygen reaching the metal surface probably has the greatest influence. In atmospheric corrosion, any moisture present on the surface of the metal is saturated with oxygen and accelerates corrosive attack by its active depolarization. In natural waters the corrosive attack is directly proportional to the content of dissolved oxygen. Solutions of alkalies and various salts attack more energetically when saturated with oxygen. In non-oxidizing acids, such as halogen acids, corrosion is accelerated by the presence of oxygen. In turn, the effect of oxygen is influenced by the temperature of the surroundings and the state of the solution whether agitated or at rest.

An important factor affecting corrosion is the distribution, or rather concentration of oxygen over the surface of the metal. Surfaces in contact with solutions rich in oxygen become cathodic while surfaces shielded from oxygen become anodic and are hence more subject to attack. The effect is not to increase the total corrosion, but rather to concentrate the corrosion, which would otherwise take place over the whole area, on the non-aerated surface. This interesting phenomenon explains the increased corrosion of protected surfaces, corners, etc., frequently observed. It also explains in great measure the pitting that occurs in seemingly homogeneous metals. There is little question but that apparently sound metals are frequently threaded by minute cavities and intercrystalline cracks. This applies not only to cast metals but to rolled metals as well. If once liquid can enter such cavities their interiors will constitute surfaces inaccessible to diffusing oxygen, and severe attack will result. Since the rate of attack is determined by the supply of oxygen to the whole surface outside the cavity, and since it is all concentrated on the small area of the cavity itself, the rate at which corrosion bores into the metal will be very great compared with the attack on the remainder of the surface. This explains the pitting action frequently observed, and also the intense localized attack which takes place in the strained metals where the surface has been roughed and minute cavities opened up. Such regions, being shielded because of roughness or otherwise to the diffusion of oxygen, always corrode more rapidly than smooth metal surfaces where the small cavities or porosities have been filled up.

Surface Films

The effect of surface films in inhibiting corrosive attack is of great importance. More properly it is a condition depending upon the composition of the metal as well as upon external factors, since the formation of protecting films is dependent upon the chemical character of the metal itself.

This property of metals is of considerable importance when considering resistance to atmospheric corrosion. Such metals as zinc, aluminum, lead, nickel, and copper form protective oxide coatings in air which retard further corrosion. Iron carrying a small proportion of copper when exposed to the atmosphere forms a hard, dense layer of rust which seems to have much to do with the well known resistance of the copper bearing steels to atmospheric corrosion.

Because of its chemical affinity each alloy or metal in contact with some other substance forms a coating, or surface layer, which is a compound of the metal itself and one or more of the elements present in the surrounding medium. This layer acts as an insulator and, if insoluble, protects the metal underneath, if soluble, or alterable, the coating disappears as rapidly as produced and the attack continues.

Illustrations of this are numerous. Lead in contact with sulphuric acid forms an insoluble sulphate coating which renders lead one of the most useful metals for the construction of sulphuric acid plants. If, however, the concentration of the acid exceeds about 80 per cent (boiling) the sulphate coating becomes soluble and attack on the metal progresses. In hard waters, lead forms an insoluble carbonate coating which protects against attack; in soft waters, where CO_2 is present, soluble lead salts are formed and the metal corrodes more rapidly. Zinc forms an insoluble hydroxide and, if conditions are favorable for its formation the zinc resists attack. The effect of nitric acid and oxidizing agents in producing the passive state in iron-chromium alloys is a somewhat similar illustration of this phenomenon. The use of sodium silicate in domestic hot water systems to form a protecting scale on the inside of iron pipes is an artificial means of producing such a protective coating. Sodium silicate when added to water in small quantities is usually broken up into SiO_2 and NaOH. The colloidal SiO_2 being precipitated with ferric hydroxide builds up a dense and adherent film with high corrosion resistance.

Regarding influences tending to localize attack and to produce pitting, the effect of oxygen deprivation in accelerating corrosion in minute cavities and porosities has been discussed. Variations in the concentration of dissolved substances in solution produce "concentration cells," the metal in contact with the more diulte portion of the solution becomes anodic and hence more rapidly attacked. Similarly, permeable coatings, such as rust, which forms on iron and steel and tends to exclude oxygen from the surface, renders the underlying iron anodic, and the areas to which oxygen has free access cathodic. The familiar water line attack may also be explained as due to different concentrations of oxygen.

The effect of temperature in modifying the rate of corrosion is of great importance. In acid solutions, increase in temperature has a marked accelerating effect, particularly in non-oxidizing acids. The effect is probably due to increased depolarization and lowering of the hydrogen overvoltage on the metal. With alkali solutions, there is also an increased rate of attack, but this is less than for acids. Increase in temperatures generally decreases the viscosity of the solutions and increases the conductivity of electrolytes and in this way increases localized attack. The effect of temperatures also influences the concentration of dissolved oxygen supplied to the surface of the metal. As long as no oxygen is permitted to escape, the corrosion rate steadily increases with increase in temperature.

Agitation increases the rate of attack mainly because more oxygen is conveyed to the surface of the metal. Increased motion of the liquid surface exposed to the air line increases the supply of oxygen by bringing unearated liquid to the surface. Furthermore, agitation sweeps away deposits of the products of corrosion which might tend to insulate, as it also brings fresh solution to the metal surface. In the absence of oxygen, the surface exposed to the higher velocity becomes anodic with consequently increased local attack. It has been found also that with mechanically entrapped air, as in bubbles, the rate of corrosion is much greater than when air is carried in solution, as the air bubbles remove the products of corrosion more effectively than a solution free from bubbles. Obviously, also, if the liquid carries foreign material such as products of corrosion, crystallized salts, sediment, etc., the effect of erosion will also be an important factor in increasing the attack.

Electrolytes

A most important external factor causing corrosion is the presence of electrolytes in solution. This is the chief cause of corrosive attack in chemical and similar industries. The electrolytes may consist of various acids, salts, bases, etc., the action of which will be dependent upon the concentration, temperature and presence of impurities.

The rate of corrosion by acids decreases in general with increase in concentration; that is, dilute acids attack more energetically than concentrated. Iron or steel is energetically attacked by dilute sulphuric acid, but the concentrated acid has so little effect that these metals are regularly used for shipping containers. Aluminum is attacked by dilute acetic acid, but the concentrated acid has little effect. However, the action of any acid may be much modified by the formation of protective coatings and similar phenomenon. The chief characteristic of the corrosion by acid solutions is the evolution of considerable amounts of hydrogen or other gases, and the formation of salts which may or may not be soluble in the solution.

Alkalies do not attack as energetically as acids. Certain metals, however, are an exception to this—notably aluminum.

Salts in solution either act to retard or increase corrosion depending upon their nature, concentration and other factors. As a general rule, corrosive attack increases with the concentration until it reaches a maximum (the critical concentration) then decreases until a low figure is reached (the limiting concentration). The critical and limiting concentrations are dependent as is all corrosion, upon temperature, agitation, oxygen solubility of the solution, etc. which will vary with each salt.

Considering metals and alloys as a whole, the character of resistance to attack is dependent very largely upon the inherent chemical affinity, or better "degree of inertness" to certain other elements, notably oxygen, sulphur, the halogens, etc., and upon the way in which this is modified by alloying constituents. Thus, in a metal inherently resistant to the attack of acids, resistance will be increased by suitable increase in silicon content; and similarly, increased resistance to alkalies is obtained by increasing the nickel content. Because of the outstanding individual characteristics and resistance of certain metals to definite corrosive materials, corrosion resistant alloys may be divided into groups depending upon the predominating alloying metal. Hence, we have the iron-silicon alloys, iron-chromium alloys, nickel and high nickel alloys, copper alloys including brasses and bronzes, the aluminum alloys, etc., each with a more or less well defined sphere of usefulness.

Of the commercial metals, iron, including steel and cast iron, is the most used as a material of construction for various manufacturing processes; and if chemical industries are included, lead will be a close second. Taking into consideration low cost, ease of working, strength, availability in any desired form and resistance to corrosion, iron in some one of its forms possesses all but the last property to a greater degree than any other metal. Even as regards corrosion, its usefulness is very great under certain conditions. It has good resistance to alkali in almost all concentrations and is practically standard for equipment for handling alkali solutions of all sorts. It has the distinct advantage of being practically immune to the action of concentrated sulphuric acid and is regularly used for handling sulphuric acid in strengths above 85 per cent. As sulphuric acid is the most important single chemical and more processes are carried out with sulphuric acid than any other reagent, the importance of iron in chemical industries may readily be appreciated. Many other chemicals if anhydrous will not attack iron, liquid chlorine, liquid sulphur dioxide, liquid ammonia, liquid hydrocyanic acid, etc., and are regularly shipped in steel drums or tanks, and even in tank cars. Nitric acid readily attacks iron or steel, and if upwards of 25 per cent sulphuric is added the attack stops. Consequently the greater proportion of nitric acid shipped throughout the country is shipped as "mixed acid" in steel drums or tank cars.

Because of its excellent mechanical properties and low cost numerous attempts have been made to improve the corrosion resisting qualities of iron and steel, and these attempts have borne fruit in the development of two important classes of iron alloys—the iron-silicon and the iron-chromium alloys. The increase in corrosion resistance unfortunately has been at the expense of some other valuable property, particularly with the iron-silicon alloys.

Iron-Silicon Alloys

Some 18 years ago Jouve showed that cast iron high in silicon possessed remarkable resistance to attack by acids, and this lead to the introduction of such alloys as Duriron, Tantiron, Corrosiron, etc. These are iron-silicon alloys containing 14-16 per cent silicon with low carbon, phosphorus, manganese and sulphur. They are resistant to practically all commercial acids except hydrochloric and hydrofluoric. Unfortunately, the high content of silicon destroys the toughness and workability of the iron and in consequence these alloys are extremely hard and brittle. Nevertheless, because of their excellent resistance to dilute acids they are widely used; but as the metal is unworkable can be produced only in shapes which can be cast, which greatly restricts their use.

The improvement of the corrosion resisting properties of iron has also been accomplished by the addition of small proportions of copper (.20 to .40 per cent), yielding the well known copper bearing steels. These are used with considerable success where the metal is exposed to wet and dry weather conditions, and similarly favorable results have been obtained where the metal is painted or coated, there being considerably less attack than with similar compositions which are free from copper.

Iron-Chromium Alloys

The introduction of the iron chromium alloys of the "stainless steel" class by Brearley in England and Haynes in this country some 14 or 15 years ago, and more recently, the development of the "stainless irons" marks a signal advance in the metallurgy of corrosion resisting alloys, and promises to be even more important in its final results than was the development of high speed steel. The original alloys contained 12-14 per cent chromium with carbon about .30 per cent but various modifications of the original composition are in use with chromium ranging up to 30 per cent. These alloys are eminently satisfactory in many respects, being strong and tough, which properties are well retained at high temperatures. To this maintenance of strength, other advantages, as resistance to oxidation at high temperatures, and to abrasion, may be added. The original low-chromium high-carbon alloys did not show maximum corrosion resistance until heat treated, and this lead to the development of the low-carbon, or "stainless iron" alloys, known under the names of Enduro, Ascoloy, Delhi, Carpaloy, etc. In these, carbon is held around .10 per cent or lower and the corrosion resistance is only slightly modified by heat treatment; in conseqence they give excellent service in any condition.

The iron-chromium alloys have found such extended usage that a complete list of applications would be too long for this discussion. They are practically free from corrosion in moist air, sea water, superheated steam, hydrogen sulphide and sulphur dioxide. With high resistance to many organic and inorganic acids they have complete immunity to nitric acid (free from chlorides) in any concentration, to alkali carbonates, caustic alkali solutions, oxidizing agents in general, fruit and vegetable acids, etc. Hydrochloric and halogen acids attack the chromium alloys energetically; sulphuric acid also attacks, but its action may be inhibited by the presence of ferric or cupric sulphates.

Numerous attempts to improve still further the excellence of the iron-chromium alloys by the addition of other elements, as copper, silicon, molybdenum, tungsten, nickel, etc. have resulted in a host of patents out of all proportion to the number of really useful alloys. Copper is chemically the antithesis of chromium, being notably attacked by oxidizing agents, and little affected by sulphuric or hydrochloric acids, hence its addition is objectionable on theoretical grounds. Practically it increases resistance to compounds of the halogens, and reduces resistance to nitric acid. The effect of small amounts of copper on the physical properties is apparently negligible. The addition of silicon, on the other hand, is beneficial as regards oxidation resistance, such steels (low-chromium) being extensively used for valves for internal combustion motors. Silicon, if in considerable amount decidedly reduces the toughness and impact strength of the metal. Molybdenum and tungsten both increase corrosion resistance, the former being the more beneficial of the two. With the addition of about 2 per cent molybdenum the resistance to both organic and mineral acids is decidedly increased, the physical properties and working qualities are apparently also somewhat improved.

Chromium-Nickel-Iron Alloys

The addition of nickel to the iron-chromium alloys has greatly widened their useful field. There are two groups of these—the high-nickel low-chromium alloys such as nichrome, chromel, Q alloy, etc., which have high resistance to oxidation at high temperatures, also high electrical resistance and are used accordingly; and the high-chromium low-nickel alloys which are virtually stainless steels with nickel added, such as Staybright, Anka, "V.2.A.," etc.

The addition of a small amount of nickel to the 12-14 per cent chromium analysis is probably without important effect; with 2 or 3 per cent or more the air hardening tendency is increased and annealing rendered more difficult. With 6 to 7 per cent nickel and 18-20 per cent chromium the alloy becomes austenitic and not susceptible to heat treatment. This is an excellent alloy as the corrosion resistance in general is greatly increased. Numerous reagents which attack the nickel free stainless alloys are without effect on this composition; in particular resistance to sulphuric acid is considerably increased. Further the toughness and impact strength are improved—the latter especially—as is the weldability of the metal, an important item from the standpoint of fabrication. The alloy, however, tends to harden up more readily on cold working and requires more frequent annealing; and on account of its being austenitic, similar to manganese steel, it is occasionally difficult to machine.

The addition of nickel to steel was originally for the improvement of physical properties, but it was subsequently found that it increased the resistance of the steel to rusting, some 15 per cent, howver, being necessary to produce a worthwhile effect. Steels with 25 per cent nickel are used for submarine periscope tubes, marine bolts and nuts, pump rods, etc. The wellknown "Invar" containing 36 per cent nickel is very incorrodible, and this, coupled with an extremely low coefficient of expansion has lead to its extended application in scientific instruments, etc. The outstanding property of nickel to the industrial chemist is its virtual immunity to the attack of caustic alkalies in any concentration and at any temperature, in which it is surpassed by no other commerical metal; and which quality it imparts proportionately to its content to those alloys which contain it. Nickel is, however, readily attacked by hydrogen sulphide and other sulphur compounds so that nickel alloys are not suitable for resisting sulphur corrosion. This unfortunate quality also extends to the high-nickel-chromium alloys which are relatively useless under such conditions.

Non-Ferrous Alloys

The most important of the non-ferrous nickel alloys are Monel Metal and its never analoges Mond-70 and Corronil. Originally obtained as a natural alloy of approximately 2/3 nickel with the balance copper by roasting and reducing the Bessemer matte from the Ontario nickel ores, Monel is now made "synthetically," and is widely used in chemical and other industries. It is a true solid solution, and in it the corrosion resisting qualities of nickel are combined with the greater workability of copper. It has excellent physical properties, is unattacked by atmospheric moisture (except surface tarnishing) and salt water. It shares the corrosion resistance of pure nickel to caustic alkalies, and is successfully used under mildly acid, and in certain instances, to even strongly acid solutions. It is not attacked by fatty acids and is little attacked by chlorine. The textile industry employs it extensively for dyeing machinery where it gives excellent service, and is considered standard for such equipment. Nevertheless, it shares the weakness of copper in that it is attacked by nitric acid and by oxidizing agents in acid solutions; concentrated hydrochloric acid, and ferric chloride attack it, likewise ammonia and the amines. Owing to the high cost of Monel metal and the considerably lower cost of the stainless-irons these are replacing it in many industries.

The copper alloys such as the brasses and bronzes present interesting peculiarities as regards corrosion. Pure copper is little attacked by concentrated hydrochloric acid, but if oxygen is present corrosion takes place very rapidly, due to the formation of cuprous chloride and its oxidation to the more soluble cupric salt. The copper alloys are therefore restricted to conditions where severe oxidation and strongly acid conditions do not exist simultaneously. Copper can be used for glacial acetic acid, while brass and bronze are used in connection with fatty acids of all sorts, provided conditions are not oxidizing. Copper is also resistant to alkalies, except ammonia. Aniline and similar amino-hydrocarbons such as the toluidines, xylidines, etc., because of their similarity to ammonia attack copper in the presence of oxygen. Owing to its ready attack under oxidizing conditions copper is useless in connection with nitric acid. Dyes and dye solutions in general seriously corrode copper apparatus; and in processes for the manufacture of various dyes the presence of copper is practically fatal.

Various attempts have been made to improve the corrosion resisting qualities of copper alloys by substituting nickel wholly, or in part, for the zinc and tin of the older brasses and bronzes. This has resulted in the development of a number of what might be called "nickel brasses," such as aterite, Davis metal, everbright, adnick, ambrac, etc. which may be used in contact with salt solutions, caustic alkali solutions, chlorine bleaching solution, and dilute sulphuric acid. In addition, these alloys are usually white in color and tarnish slowly in the atmosphere, and consequently are useful for plumbing fixtures and other domestic equipment. Everdur, a copper silicon alloy was originally developed for resistance to hydrochloric acid, but share the weakness of other copper rich alloys in being readily attacked under oxidizing conditions. It has, nevertheless, excellent physical properties, casts easily, and is a suitable metal where a non-ferrous alloy of high strength is required for use under mildly corrosive conditions.

The alloys of aluminum and the metal itself are characterized by their high resistance to organic acids (except formic) and to concentrated nitric acid (over 68 per cent); and by their low resistance to the halogen acids and caustic alkalies, with the exception of ammonia and soap solutions. The resistance of aluminum is not due to the inertness of the metal itself, but to the formation of a very stable layer of oxide or hydrated oxide, as has already been described. The pure metal is used in connection with acetic acid, neither the concentrated acid nor the glacial having appreciable action even at the boiling point. Aluminum may also be used for such acids as acetic anhydride, phthalic anhydride, and for the concentrated nitric acid. As a material for the latter, however, it is distinctly surpassed by the iron-chromium alloys. The so-called "mixed acid" attacks aluminum, as does sulphuric in the higher concentrations. Phosphoric and oxalic acids also attack. Organic compounds such as aniline, the naphthols, and naphthylamines also attack aluminum. The organic acids such as oleic, palmitic and stearic do not attack under ordinary conditions, if however, they become anhydrous they attack the metal vigorously. Sulphur dioxide and hydrogen sulphide, however, have no effect on aluminum, even in the presence of steam at elevated temperatures.

A very useful class of aluminum alloys—although more correctly these are copper alloys—are the aluminum bronzes, such as alcumite, ampco, etc., containing about 2-6 per cent iron, 8-11 per cent aluminum, with the balance copper. They possess excellent resistance to dilute acids, such as sulphuric, hydrochloric and acetic, also to caustic alkali solutions and to chlorine gas; but owing to their very high copper content are attacked by nitric acid and oxidizing agents. Concentrated hydrochloric acid also attacks. These alloys are valuable and find extensive uses in many industries, the tensile strength is about equal to that of a mild steel, and the abrasion and wear resisting qualities are also good. Their production, however, presents some difficulties and they must be handled with considerable care. So far they have not been produced in seamless tubing.

One advantage of aluminum is that its compounds are colorless and non-toxic, and hence cause no discoloration of the product when present as impurities, nor are they dangerous to health. The relatively low strength of aluminum and its softness tend to limit its use to a considerable extent.

Of the commercial metals, after iron, lead is probably the most important, particularly in chemical industries. This is because of its high resistance to sulphuric acid and its resistance to many dilute acids and acids of low strength. The resistance of lead to corrosion is due, as with aluminum, to the formation of an insoluble protective film, which however, no longer protects when the concentration of the acid is increased beyond a certain limit (about 85 per cent for sulphuric). Like some other metals, lead is attacked by hydrochloric and nitric acids; acetic acid also attacks. Lead has the advantage of workability and although lacking in physical properties is extensively used because of this workability and the ease with which repairs may be made. Various hard lead alloys are on the market, the most important of these are the lead-antimony and the lead-silicon alloys. The antimony alloys contain up to 15 per cent or more of this metal, by which resistance to hydrochloric acid is increased, as is stiffness and strength. Copper is also used to improve mechanical properties, the usual percentage being about 2 per cent.

Choice of an Alloy

Given a definite corrosion problem the selection of the proper alloy is based upon the character of the conditions to be withstood; i.e., whether an acid or alkaline resistance is desired, whether conditions are oxidizing or reducing, etc. The selection having been made from theoretical considerations, tests, both in the laboratory and under actual plant working conditions should be made. Laboratory tests of specimens suspended in beakers of solutions are to be regarded as a first approximation only because of the virtual impossibility of exactly reproducing plant working conditions. To estimate the prospective life of a piece of apparatus by calculations based on a record of inches penetration per month or equivalent numerical corrosion coefficient is hazardous to say the least. A much more accurate laboratory method is to compare the proposed metal with that already in service by running simultaneous tests of each under similar conditions approximating as closely as possible those in the plant. By such means it will be possible to say quantitatively how much better the new alloy appears than the old, and from this to make a more reasonable prediction.

In all cases, unless there is previous experience on which to base a prediction, the practical works test of a large-sized sample of the alloy should follow any laboratory test, and from the result of this assumptions may be made of the suitability of the metal.

In this connection it may be well to point out a very prevalent fallacy; namely, the tendency to consider the salt spray test as a criterion of general corrosion resistance. Originally developed at the Bureau of Standards as a test indicative of the action of salt water, with which the Navy Department is vitally concerned, the use of this very severe test has outgrown all reasonable limits. As was remarked earlier in this discussion there is no one universally corrosion resistant alloy or metal. Similarly there is no universal corrosion test; and to judge the general usefulness of an alloy from its ability to withstand salt spray is just as incorrect as to assume that resistance to nitric acid implies resistance to hydrochloric as well. The results of laboratory tests, including the salt spray, are accurate to the conditions maintained during those tests and no more. Any extended interpretation of the results beyond the actual conditions is very unwise.

Having considered the theoretical side of the subject, the practical side should also be considered, and this is concerned with the procurement of the alloy or metal in proper form for the construction of the apparatus or equipment, and at this point considerable difficulty may be encountered. Unfortunately some of the most useful corrosion resistant alloys are extremely difficult to fabricate, and have not yet been produced in all the forms desirable. Some cannot be drawn into seamless tubing, others are cast with great difficulty, others cannot be rolled into sheets, etc.; so that in many cases the engineer's ability will be taxed to design the apparatus so as to circumvent these difficulties.

It is most important that all parts of a piece of apparatus which enter into contact with a corrosion material be composed of the same metal throughout. It is not sufficient to avoid contact between merely unsimilar metals, but the composition of similar metals, in certain instances, must be closely identical. Stainless iron with 12-14 per cent chromium in contact with a similar alloy containing 17 per cent chromium becomes distinctly anodic even in the presence of nitric acid; and the combination of two such alloys in contact with more energetic reagents should be avoided. The steel and alloy manufacturers have appreciated this condition and are making all efforts to produce their respective material in all necessary forms. If the metal which is to be used is not obtainable in all the forms desired, the parts which are constructed of dissimilar metals should be carefully insulated so as to avoid the possibility of electrical contact.

In dealing with problems of corrosion in manufacturing processes or otherwise there are two fundamental considerations which must be answered at the outset, either individually or together. First, is the use of a corrosion resistant metal for the purpose of increased economy because of anticipated longer life of the equipment; or, is the use of such metal to eliminate catalytic action which would result in decreased yield of the product manufactured, or its contamination by the products of corrosion.

The cost of the alloy must be considered in estimating the economy to be effected by its use, and here the Law of Compensation again enters, as it invariably seems that the more satisfactory and desirable are the properties of a metal the higher its cost. This cost may seem in many cases unreasonably high. Many of these alloys are made from ordinary metals of commerce, and would appear to present no difficulty in melting or in the production of the simpler shapes. This is, however, not always so, for unusual care is necessary in handling special alloys, each one having peculiarities of its own which are mastered only after long and costly experience. Also the scrap losses in manufacture may run very high, as is the case with the stainless chromium alloys, the scrap being of relatively little value because not economically remeltable.

In any event the cost of the alloy should not be considered as the initial cost of the apparatus, but as a charge to be distributed over the total quantity of product produced by a given piece of equipment before replacement is necessary; that is, on the service given. The avoidance of shutdowns and delays for repairs and replacements, with the greater production obtained thereby must also be considered. Before replacing ordinary iron or steel at a few cents per pound with an alloy costing 30 or 40 cents the plant engineer must be reasonably assured that a commensurate longer life can be expected. It is difficult to estimate in exact figures the saving affected by avoidance of shutdowns and delays unless definite information is obtainable from experience with a similar installation. If, as a basis for argument, we assume that the saving thus affected will offset by one-half the increased cost of the new metal, then such new metal must give some five times the service of plain iron or steel to result in any economy. If this is indicated by a works test, then the advisability of using such metal should not be questioned. The construction of a stainless-iron tank car for conveying nitric acid is perfectly feasible from the standpoint of fabrication and corrosion resistance. If there are sufficient demands for the transportation of this quantity of acid, then the economy of such a car, as compared to the present cost of glass carboys and the expense of handling same, will be sufficient to justify its cost.

As regards avoidance of catalytic action the selection of proper alloys or metals is vitally important and the question of cost, unless exorbitant is of small account. In many processes the undesirable products of corrosion are removed by subsequent treatment; and the cost of such refining operations will determine whether the use of a metal which eliminates them is justified.

The National Power Show

The Sixth National Exposition of Power and Mechanical Engineering will be held at the Grand Central Palace, New York, from December 5 to 10 inclusive, and at the same time as the exposition is held the annual meetings of the American Society of Mechanical Engineers, American Society of Refrigerating Engineers, will be held. Numerous other organizations will meet at the same time as the exposition; some of these will meet jointly with, or in bodies attend the exposition.

The number of exhibitors this year is already considerably increased over last year. There are now more than 500 exhibitors and the exhibits will include approximately some 400 exhibits of power generation, distribution and utilization; between 200 and 250 exhibits will include heating and ventilating equipment, and refrigeration for large scale industries, factories, office buildings, apartment, public and assembly buildings, and homes. Between 100 and 150 exhibits will show instruments for control of time, pressure, temperature, volume, or what other element requires precision in its measurement or recording. There will be about 125 exhibits or more of machine shop equipment, including metal and wood working machines, transmission equipment, tools and machine tools, and in this phase of the exposition's activities, there has been a marked increase in number of exhibits. There are many new outstanding exhibits of transmission equipment. There will be numerous exhibits of materials handling equipment.

Many unusual educational exhibits are planned and with an increasing attendance of representative engineers, manufacturers, technical men, construction men, plant and building operators and others, it is expected that this coming exposition will prove a remarkable engineering achievement.

The advisory committee of the exposition cooperating with the management comprises: I. E. Moultrop, chairman; Homer Addams, F. Paul Anderson, N. A. Carle, Willis H. Carrier, Fred Felderman, C. F. Hirshfeld, O. P. Hood, John A. Hunter, E. B. Katte, R. T. Kent, John H. Lawrence, Fred R. Low, David Moffat Meyers, R. F. Pack, Fred W. Payne, Calvin W. Rice, Charles F. Roth and Charles M. Schwab.

The managers of the exposition report that the exposition will this year occupy four full floors of the Grand Central Palace and that excepting a few spaces still available, all space is engaged. All inquiries should be addressed to the International Exposition Company at the Grand Central Palace, New York, N. Y.

Wheeling Steel Corp's New Skelp Mill

Mesta Machine Company Has Designed New Type Continuous Electrically Driven Skelp Mill Using Edging Roll. Special Interest Attached to New Type Electric Flying Shears

By DON N. WATKINS

IN accord with the forward progress in the rolling of steel products by the large steel corporations of the country, Wheeling Steel Corporation has recently put in operation at their Benwood works, a new skelp mill. A mill which is capable of producing long strips of skelp at the rate of 600 to 1,200 ft. a minute, and which rolls a billet complete in 45 seconds.

The feature that strikes the eye as one enters this new mill for the first time is the ease with which the skelp is rolled, and yet the rapidity and the precision which accompanies the operation. Another thing that seems remarkable is the lack of heavy, bulky machinery which has so long been a prominent factor in our rolling mill operation. It is proven the mills that were once unsightly, as we might say, in their appearance, can be erected most compact.

To provide billets for the mill the largest Chapman-Stein continuous recuperative heating furnace of its kind in the country has been erected. To provide gas for this furnace, a gas plant consisting of two continuous full mechanical producers of a diameter of 10 ft. are used. Even the last word in efficiency is included in the gas house as the producer coal is fed by elevator conveyors and the entire gas making process, even to the carrying off of ashes is accomplished by mechanical means.

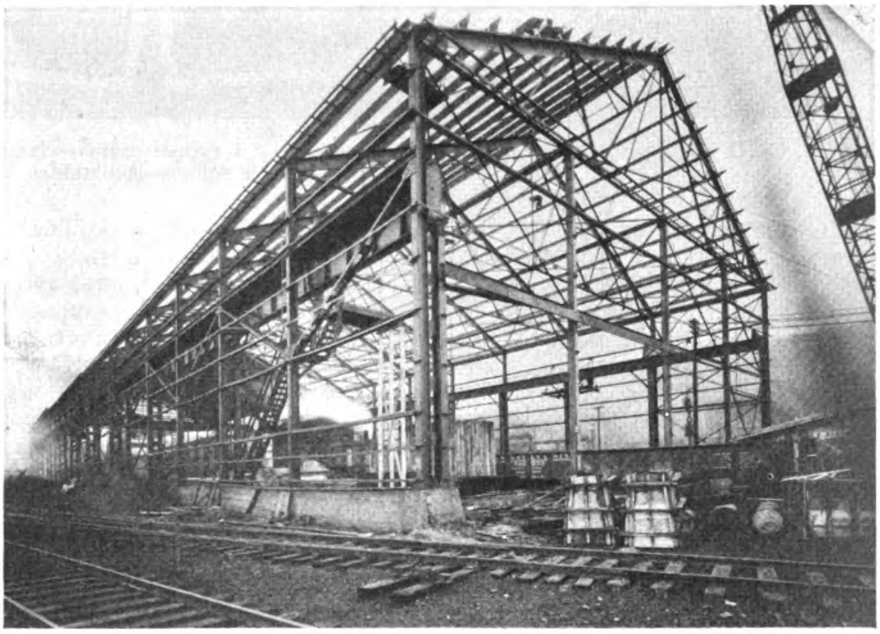
This furnace has a rate of 35 tons of steel per hour, although it is the expectations of the operators to heat 45 tons or more in an hour. The furnace is 30 ft. wide by 40 ft. long with the floor sloping downward from the charging to the discharging end, the billets and slabs moving down an incline as they are heated. From the time the billets are charged into the furnace until they are sent to the mill is approximately 1½ hours.

Efficiency is carried in the design of the furnace in every particular. A mechanical charging unit operated by electricity pushes the billets into the furnace and on to the moving supports. Once inside the furnace the billet or slab moves slowly sideways down the slope of the furnace, and by the time it reaches the lower end it is heated, ready for rolling.

The continuous skelp mill which is electrically operated, consists of 10 stands of horizontal mills and four sets of vertical edging rolls; the stands being placed in pairs and each pair being separated by one set of vertical edging rolls.

Each set of rolls is set to reduce the size of the billet as it passes through, and the rolls in succeeding stands are adjusted to increased speed to compensate for the increasing length of the billet as it proceeds through the mill.

The edging rolls perform two functions. They prevent the billet from spreading beyond the desired width, and they shape the edge as it is being rolled by squeezing it edgewise as it passes between them. The edging rolls revolve in synchronism with the horizontal mills. After the piece is delivered from the last set of rolls it passes through an electric rotary flying shear where it is cut into proper lengths.



FIGS. 1 and 2—Skelp mill buildings during erection.

A Mesta patented electric flying shear is used to cut the steel after it has passed through the last set of rolls. This shear consists of two rows of unequal size each of which carries a knife. By a system of gearing the two knifes are brought together at defi-

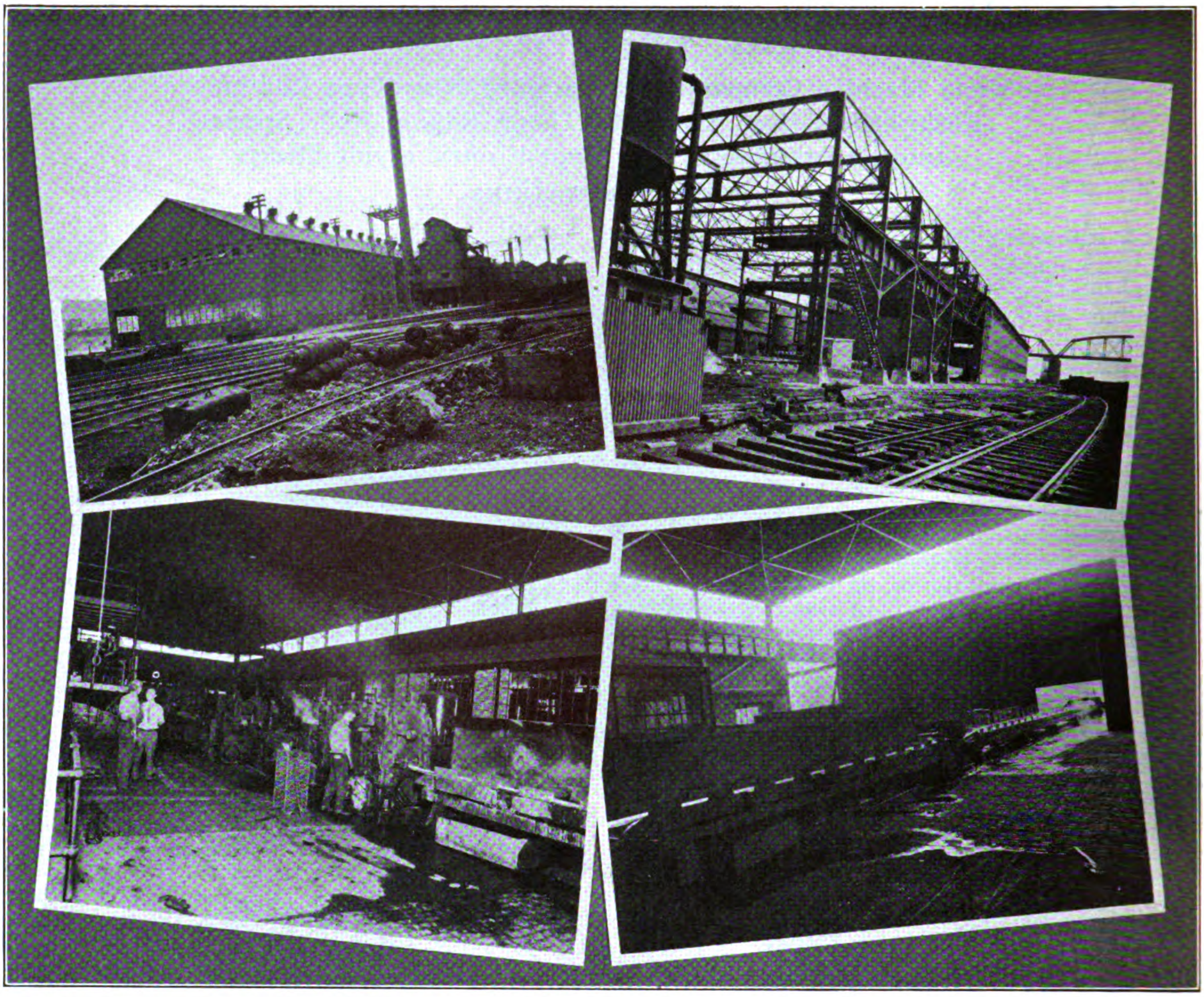


FIG. 3 (upper left)—Skelp mill building. FIG. 4 (upper right)—Stock yard. FIG. 5 (lower left)—Rolling skelp. FIG. 6 (lower right)—Roll tables from mill.

nite intervals, thus gauging the length of the steel to be cut. The speed of the shears synchronize with the speed of the mills to give the correct relative operation and to cut the steel to the proper length. The skelp is passing through the shears at an approximate speed of 1,200 ft. per min. when the shears make their cut.

After the skelp is rolled to proper thickness and cut to the proper length, it continues on its way by passing over a continuous belt driven conveyor, the conveyor being over a 100 ft. in length, until it passes beyond the end of the building where it is packed and passes slowly up the cooling tables. At the end of the cooling tables each pile of finished skelp is weighed by the latest type of automatic scales and the crane loads it on the cars to be moved to the tube mill.

The mill is adjustable and may be set to roll skelp of from 2 to 12 in. wide from a billet or slab 30 ft. or less in length.

The mill is entirely electrically operated, all the electrical equipment being located in a motor room within the main mill building. All the electric motors and switch board equipment was furnished by the General Electric Company. The motor tie up being as follows:

The a.c., which is furnished by the Wheeling Electric Company, is transformed to d.c. to supply the mill motors by two composite machines, one being composed of a motor and two generators and the other, a motor and one generator.

The larger of the two composite machines has a motor of 5,600 hp. output which drives two genera-

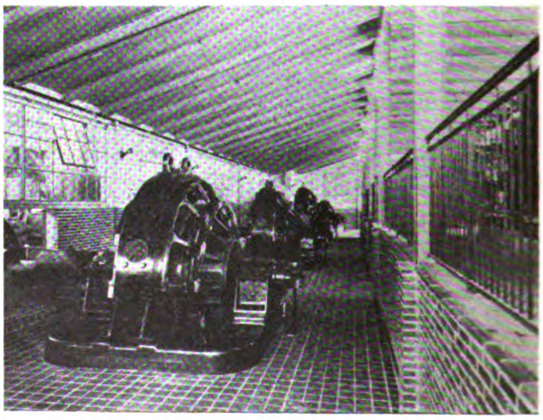


FIG. 7—General Electric Company motors which drive skelp mill.

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tors each having a nominal capacity output of 2,000 kw. and a maximum capacity of 3,000 kw. for two hours.

The smaller of the machines has a motor of 500 hp. output capacity which drives a generator having a nominal capacity output of 500 kw. and a maximum capacity of 750 kw. for two hours.

A 500-hp. motor drives the first two stands of horizontal rolls while all the other horizontal stands are driven by three 2,000-hp. motors. One 2,000-hp. motor being used to drive the first four stands after the two sets of roughing rolls, and each of the two remaining large motors are used to drive two of the remaining four stands.

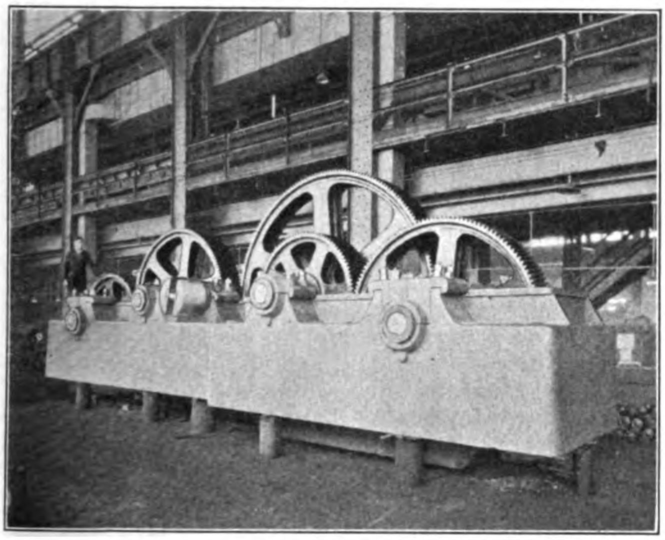


FIG. 8—Helical drive for four stands.

In Fig. 8 is shown the 2,000 hp. Mesta single helical gear drive which transmits the power from the 2,000 hp. motor to the four stands of rolls, mentioned above.

The vertical edging rolls and the rotary flying shears are each driven by directly connected individual motors.

In the basement of the power house is a modern air washing device which furnishes clean pure air to the motors. Complete oiling equipment designed and installed by the S. F. Bowser & Company is also located in the basement.

The complete electrical installation was made by the General Electric Company. The mill proper was designed and built by the Mesta Machine Company, but erected by the Wheeling Steel Corporation's mechanical department. The main mill building is of sheet steel construction 375 ft. long by 97 ft. wide, with a structural steel runway for the overhead crane extending for 175 ft. on out over the cooling tables. The motor room which is built within the large building is entirely of brick, concrete, and steel.

Importance of Correct Roll Centering

The question of roll breakage is one of vital importance to every man concerned with the production of rolled products. There are many reasons for failure, which are more or less known, but in some instances, it is rather difficult to determine the exact cause.

It is not the purpose of this article to enumerate or describe all the reasons for failures, but merely to point out how roll performances may be improved by carefully watching the condition of the centers.

The centering of a roll may seem to be rather remotely related to roll breakage, but it is manifestly impossible to turn the necks or body of sheet mill rolls circular or concentric with relation to each other on imperfect centers. The cam or eccentric action resulting from imperfect centering will not only set up excessive strains, but will also produce sheets of varying thickness.

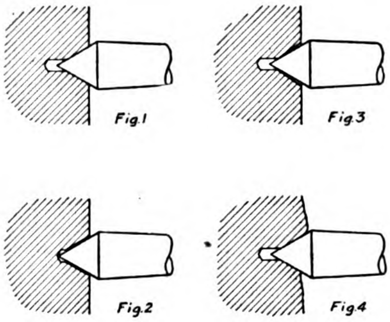
In the rolling of sections, the plasticity of the hot metal and the greater strength of the rolls used will reduce the danger of breakage, but in the rolling of sheets, a slight eccentricity may result in failure due to the absence of "give" in the sheet, and the relative weakness of the roll.

Eccentricity May Cause Failure

Eccentricity in a roll does not always result in failure, but it is a contributing factor and even though an eccentric roll may be used for some time, the repeated stressing occurring with each revolution during rolling, may weaken it to such an extent that it will eventually break.

In the turning of a roll, the first step is centering, and the utmost care should be exercised in performing this operation. After locating the center, a ½-in. hole is drilled to a depth of about 1½ in., and the hole is then countersunk to a depth of about 1 in., (see Fig. 1).

It is important that the ½-in. hole be drilled deep enough, so that the point of the lathe center will be free, and not carry the roll as shown in Fig. 2. If this condition exists, the roll will not be rigidly supported while turning.



Showing correct and incorrect methods of centering rolls

It is also important that the angle of the counterbore be the same as that of the lathe center, so as to give an even distribution of the load. Only a slight difference in the angle, as shown in Fig. 3, will result in an excessive pressure at one point or another, causing undue wear.

In the event that the surface around the center is uneven, it should be spot faced. If the metal is higher on one side than on the other, as shown in Fig. 4, the lower side which has less bearing surface may wear to a greater extent and allow the center to shift.

Shifting of the center may be caused by hard or soft spots or spongy areas in the metal. In the event that such conditions are experienced, it is advisable to drill a large hole in the end of the roll, insert a plug, and re-locate the center.—The Wabbler.

Regenerators for Open Hearth Furnaces

The Form of Checker Installation Here Described Has As Its Objective, Increased Efficiency, Less Regenerator Space, Reduction in Cost of Upkeep and Fewer Shutdowns

By FRED H. LOFTUS

THE experiments of the Siemens brothers in 1857-'61 developed the basic principle which is necessary for the successful application of the open hearth furnace as a means for the manufacture of steel. These experiments related to the process of preheating the air and gas for combustion all of which was accomplished by means of regenerators. The fundamental elements required for the production of high temperature in an open hearth furnace are the regenerators and ports.

It is not a difficult matter to alter the port arrangement, but on furnaces where the capacity has been increased regenerators cannot be altered without considerable expense and loss of time. Building restrictions, loss of production and the expenditure required to enlarge the regenerator chamber place obstacles in the path of the operators. In view of this it is unfortunately true many furnaces are operating with checker work which are entirely too small and do not function to the fullest extent. With such a condition prevailing the basic principles of the regenerative furnace which were established in the years 1857-'61 are only in part utilized.

It has been the desire of every operator to obtain a checker which would give the maximum heat absorption from the waste gases, the maximum degree of preheat to the incoming air and gas together with an efficient and economic campaign.

Various Types

There are various styles of checkers but the ones most commonly used are formed from standard 9 in. brick and the 10½ x 4½ x 4½ in. checker block. These are usually laid up with a vertical flue opening of approximately 36 sq. in.

The 9 in. checker is sometimes laid up on flat and sometimes on edge. In either case there are longitudinal and horizontal flues in addition to the vertical flues. In computing the exposed area all surfaces are taken into consideration immaterial of the fact that a portion of these surfaces are not directly in the path of the gases. In so doing 9 in. checker brick laid on flat give approximately 15 sq. ft. per cu. ft. of material, 9 in. checker brick on edge give approximately 13½ sq. ft. per cu. ft. of material, and 9 in. checker brick on edge staggered give 16½ sq. ft. of surface for every cu. ft. of material; 10½ x 4½ x 4½ in. brick give approximately 8.4 sq. ft. of surface per cu. ft. of material. A straight vertical flue checkers with 5½ x 5½ opening formed from blocks 13½ x 6 x 3 has been used and given an exceedingly long campaign. It has been found this type of checker does not readily clog due to its straight flue opening. However, with such a design it is impossible to get the proper weight in a given space or the proper amount of exposed surface per cu. ft. of material. The straight flue checkers with a 5½ x 5½ in. opening permits about 6½ sq. ft. of surface per cu. ft. of material. With such a checker design the furnace clears very nicely, but does not properly regenerate the air or gas, resulting in a slower working furnace.

Area Exposed to Longitudinal and Lateral Flues

In any design of checker depending upon the area exposed to the longitudinal and lateral flue openings the efficiency of the checker will be of short duration due to the fact that there is little or no lateral circulation of gas in the checker chamber. In view of this, these openings form dead pockets in which dust and dirt rapidly accumulate, and eliminate a large percentage of exposed area. This usually occurs after a period of 125 heats or 250 heats and materially affects the operations of the furnace.

Strength

In small regenerator chambers 9 in. checkers sometimes collapse due to operating at abnormal temperatures and their inability to support their own weight when operating at such temperatures. Under such circumstances operators have substituted a 10½ x 4½ x 4½ in. block to give the necessary strength. Such a substitution will no doubt permit a longer campaign and a greater recovery or salvage of material but does not permit a sharp working checker.

It is generally conceded that a checker block should not be over 3 in. in thickness due to the fact that the heat does not penetrate over 1½ in. from the surface. Any material in excess of 3 in. in thickness is a loss as far as heat absorption is concerned.

The conditions in a regenerator cannot be fully satisfied by either the 9 in. checker or 10½ x 4½ x 4½ in. block. The larger blocks have the necessary strength but cannot be considered efficient due to the fact that they have fewer number of openings or passages for the gases to enter or leave the furnace. The material in the large block does not function to its fullest capacity owing to the thickness and the campaign is very short owing to the rapid accumulation of dirt in the lateral and horizontal flues. The 9 in. checker is efficient from the heat transfer point but does not have sufficient strength to prevent the checkers from sagging, nor sufficient weight to give a proper thermal capacity.

Present Method of Calculating

There are various methods used in arriving at proper capacity and requirements for checkers. These methods are either based on weight, cubical contents of regenerator or exposed surface. There is a wide variation in opinion of various furnace builders. In reality the requirements should be defined by the weight of checker brick, exposed surface and area of flue openings. The weight is governed by the thermal capacity required to store sufficient heat to preheat a known volume of air and known temperature for a known period of time; the exposed surface is regulated by the volume of air which must contact with the surface of the determined weight of brick in order

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to obtain the transfer of heat. The area of the flue openings is governed by the volume of waste gas passing through the checker work at the proper velocity to obtain efficient heat transfer without undue clogging.

By a simple method of computation which has been devised the proper weight for ample thermal capacity may be determined by using one pound of checker brick in each air chamber for each pound of steel produced per heat with not less than 0.06 sq. ft. of exposed surface per pound of checker brick. The size and capacity of the passages or flues through the checkers as determined by the volume of waste gas should equal 99 sq. ft. per ton of capacity for both the air and gas chambers. The air chamber should have a ratio of two to one over the gas. The flue passage capacity through the air chamber would be approximately 1.65 sq. ft. per ton. The flue passage through the gas chamber would be 0.825 sq. ft. per ton of capacity. Under ordinary furnace conditions with producer gas as fuel the area of these passages will permit a calculated velocity of 400 ft. per min. To obtain the best results in the upper portion of the checkers from the standpoint of heat transmission the total area of the passage should be such that the velocity of the gases entering the checker will not exceed 600 ft. per min. In the latter case, the area of the flue passage per ton of steel produced would be 1.1 sq. ft. for the air chamber and 0.55 sq. ft. for the gas.

Effect of Flue Area on Velocity

The velocity at which the gas travels through the regenerator is an extremely important factor. Let us assume that all vertical passages through the checkers were equally effective, which they are not, and the waste gas enters at 2,400 deg. F. and leaves at 1,200 deg. F. which for our purpose is a decrease of one-half the entering volume. With a velocity of 400 ft. per min. in the upper section of a regenerator the same flue area at the base of the regenerator would permit a velocity of 200 ft. per min. or an average velocity through the chamber of 300 ft. per min. Where the checker chamber is 12 ft. deep the period of time required for the gas to pass through the checkers would be 2.4 sec. If the initial velocity was increased to 600 ft. per min. under the same conditions the average velocity through the checkers would be 450 ft. per min. in which case the required time for the gas to pass through the checker work would be 1.6 sec. In view of the fact that all passes in a checker chamber are not effective it is not difficult to imagine a condition wherein the time element would be reduced to such an extent that the temperature drop or heat absorption would be extremely small. The importance of having a proper flue area cannot be emphasized too strongly.

On the other hand when the chamber is used as a recuperator the passages must present sufficient resistance to allow a proper element of time for heat absorption. If the flues were too large and open air would pass through too rapidly as each degree rise in the temperature in the air increases the velocity. This is the condition which prevails in straight vertical flue designs wherein the velocity of the incoming air is too great for proper heat absorption.

Providing a Constant Flow of Air

In order to produce an even flow of air to the furnace it is necessary to provide a reserve space above the checkers in which the kinetic energy of the many streams of air flowing through the checkers may be converted into static pressure with ample volume to guarantee a constant and even flow to the uptakes. This is just as essential as a supply or reserve tank is on a compressed air system. Furnaces ranging from 75 to 150 tons require approximately 65 cu. ft. of free air per min. per ton of capacity. The reserve space should not be less than one-fifth the total volume of the free air required per minute. This will allow a complete change of air above the checkers every 12 sec. which will provide ample time to eliminate pulsations and the like. The reserve space expressed with reference to furnace capacity is approximately 12¾ cu. ft. per ton.

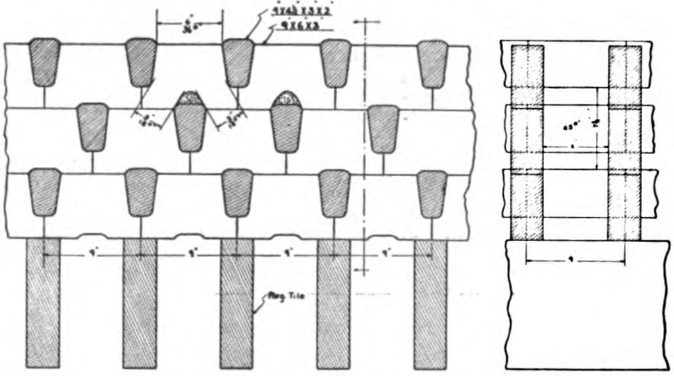

FIG. 1—Checker construction according to layout described.

Suggestions for Increasing Capacity

Fig. 1 shows an arrangement of checkers made from a series of straight vertical flues. This particular construction does not depend on the area exposed to lateral or longitudinal flues. Each passage of this checker design has a positive circulation owing to its inherent construction. The loss of surface due to accumulation does not exceed 10 per cent of the total

Description	Ordinary Type Checker		Proposed Type Checker	
Size: 10′-9x27′-0x12′-6	10½x4½x4½″	9″ edge	6x9″	6x6″
Number required	9,500	17,468	8,505 L-3 9,000 L-1	11,025 L-2 11,325 L-1
Weight	175,000 lb	153,000 lb	240,750 lb	222,500 lb
Volume	1,165	1,020	1,605	1,485
Exposed area per cubic foot	8.4	13.5	8.8	9.22
Exposed area when new	9,000	13,770	14,100	13,700
Exposed area when old	3,600	7,110	13,175	12.280
Area lost by accumulation	6,200	6,660	1,125	1,420
Total area of flues	94½	148	148	128
Cost	$931.00	$698.72	$1,396.60	$1,204.00
Per cent difference in cost after deducting additional material	11%	41%		

exposed surface which permits a better working checker with a longer campaign. The streams of gas are divided at each course of block to permit the entire column to scrub the checker surface which is essential for good heat transfer owing to the low conductivity of the gases. By forming the checkers in this manner a substantial increase in checker weight and exposed area may be obtained together with an increase in flue capacity. The increase over present methods are shown in the attached table.

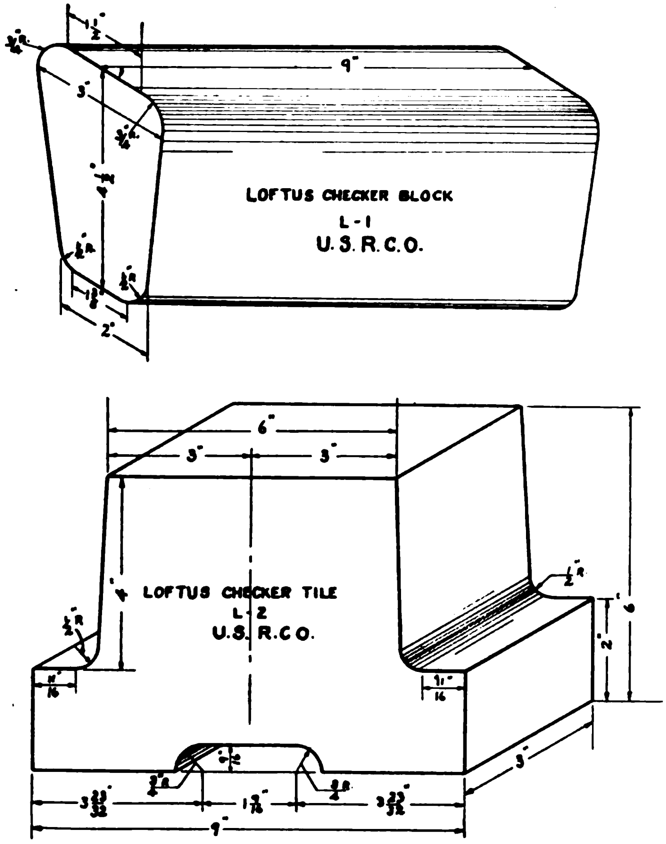

FIG. 2—New form of checker block.

The stream line blocks (see Fig. 2) which are the hot working elements have approximately twice the exposed area per cubic foot over the walls which support the blocks. Due to the fact that the blocks support no weight other than their own this is possible while the walls which support the load can be given the proper strength to meet the requirements at a high temperature. These blocks have a comparatively low resistance to the outgoing gases and offer a slightly added resistance to the inflowing air or gas which will counteract the high velocity obtained in a straight vertical flue in which we do not have the proper element of time with the comparatively large passages for the proper transfer of heat.

The arrangement shown in Fig. 1 will accommodate the majority of the present cases in which furnaces are operating with small regenerators. The 6 x 9 in. flue is designed to meet the requirements of chambers which have a small cross sectional area and are badly in need of flue capacity. The larger flue is also suggested for use in liquid-fuel furnaces where the atomization is done by means of steam. In this regard the moisture is carried into the checker and causes the unconsumed carbon and other substances to accumulate more rapidly than in other practices.

Inspection Trips During Steel Treater's Convention

During National Metal Week to be held in Detroit the week of September 19, four national technical societies will be holding their annual or special meetings, while at the same time the Ninth Annual National Steel and Machine Tool Exposition will be held in Convention Hall, Detroit.

In addition, to the largest educational industrial exposition ever held in the United States and the splendid technical programs prepared, the plant inspection program offers an unparalleled opportunity for the visitor to observe the production and manufacturing methods of some of America's largest metal manufacturing and consuming plants.

The program provides for inspection during every afternoon of the week with the exception of Monday and an additional special trip is planned for Friday morning. The schedule of plant inspection is as follows:

Tuesday afternoon, September 20—Cadillac Motor Car Company, Dodge Bros., Budd Wheel Company, Detroit Steel Products Company, Detroit Copper & Brass Rolling Mills.

Wednesday afternoon, September 21—Lincoln Motor Company, Hudson Motor Car Company, General Motors Research Laboratories, Detroit Seamless Steel Tubes Company, Victor-Peninsular Company.

Thursday afternoon, September 22—Ford Motor Company, River Rouge plant; Chevrolet Motor Company, Barnes-Gibson-Raymond Inc., Fisher Body Corporation, Park Chemical Company.

Friday morning, September 23—Packard Motor Car Company, Ford Motor Company, Highland Park plant; Parke-Davis Company, Michigan Malleable Iron Company.

Friday afternoon—Ford Motor Company at Fordson, Studebaker Corporation, General Motors Proving Grounds, Detroit Edison Company, Trenton Channel Plant.

Dry Coke Quenching System Acquired

George E. Leonard, president of the International Combustion Engineering Corporation has announced the acquisition from Sulzer Brothers, Winterthur, Switzerland of the Sulzer System for dry quenching coke which will be developed in this country by a new subsidiary, Dry Quenching Equipment Corporation.

The Sulzer system is widely used in Europe for cooling coke without the use of water. Steam is produced for power and plant purposes during the cooling process, thus diverting to useful work the sensible heat of the coke, which is at present lost by wet quenching.

The first unit in America was installed by Sulzer Brothers for the Rochester Gas & Electric Corporation where the equipment is exceeding the manufacturer's guarantee in daily operation.

The directors of the new corporation are: George E. Leonard, chairman; H. D. Savage, president; G. G. G. Hunter, vice president; George H. Hansel, treasurer; Hans Sulzer, of Winterthur, Switzerland; F. Oederlin, of Winterthur, Switzerland; E. N. Goodwin, New York.

Walter Sennhauser, at present connected with Sulzer Brothers of Winterthur, will come to this country as chief engineer.

New Three-High Blooming and Slab Mill*

Description of a Mill Built in Germany for an Italian Works. Method of Operating Discloses Several Novel Features. All Movements Electrically Controlled

MESSRS. Societa Italiana Ernesto Breda, of Milan, have recently enlarged their rolling plant by installing a further three-high (blooming and) slab-blooming mill suited for dealing with blooms weighing up to 2 tons each (Figs. 1 to 7). Blooming mills intended for rolling slabs of more than 2 tons, are usually designed as reversing twin mills with fixed bottom rolls and movable top rolls which are adjusted each time the blooms have passed through. Compared with three-high mills which always rotate in one direction only, such reversing twin mills do away with the necessity of lifting and lowering the blooms with the aid of lifting tables so as to bring them to the level of the pass between the upper and middle roll. As the rolling program of the Italian works, however, includes comparatively heavy blooms of 2 tons, besides lighter ones of about 1 ton, the three-high type of rolling mill was found to be more economical on account of the greater simplicity of its electric driving gear, and the subsequently reduced first cost.

Without changing the rolls, this three-high mill is capable of rolling blooms of 1 ft. $4^{9}/_{16}$ in. and 10 in. down to billets of 7⅛ in. and 4 in. cross-section, or to any other rectangular section within these limits; it is also able to produce slab blooms up to a width of 1 ft. 9⅝ in. The housing A contains a fixed bottom roll (a) supported in bearings, a middle roll (b) which can be lifted and lowered, and a top roll (c) designed for adjustment after each pass (Figs. 1 to 5). Owing to the very wide limits (1 ft. 3¾ in. to 1 ft. $5^{11}/_{16}$ in.) within which the top roll is adjustable, the slab pass in the centre of the rolls as well as the blooming or cogging passes on either side of the slab pass could be made very shallow. As the slab pass can, however, also be employed for the first blooming passes in drawing down blooms, it was possible to execute the rolls with the comparatively small diameter of no more than 2 ft. 5½ in. with a barrel length of 6 ft. 7 in. An ordinary three-high mill with one fixed and two adjustable rolls (not adjustable during operation) would have required rolls at least 2 ft. $9^{7}/_{16}$ in. to 2 ft. $11^{7}/_{16}$ diam.; which latter however, would not be suitable for three-high mills. Ordinary three-high mills have an additional disadvantage inasmuch as their fixed rolls can only be used for a very limited rolling program when definitely grooved, the rolls having to be changed if the billets to be produced differ widely from the previous rolling program.

Drive for Mill

The new three-high blooming mill is driven by a three-phase motor of 1,180 to 2,360 bhp. output at 115 rpm. With the aid of resistances, the speed of the motor can be reduced to 90 rpm. and even 80 rpm. in an emergency. Of course the efficiency of the motor drops correspondingly at the same time. The intermediate shaft (d) between the spindle housings B and the motors is fitted with a fly-wheel C of 22 ft. ⅝ in. diam. weighing 68 tons. The main coupling (e) connecting the intermediate shaft and the neck of the middle pinion spindle, is an Ortmann clutch designed to be controlled by hand. This type of clutch prevents axial pressure from reaching the motor in the event of one of the rolls happening to break, even though the fracture be an oblique one. This is due to the coupling being telescoped after breaking a locking ring. The coupling box, or sleeve, is arranged to break on a certain torque being reached, thus protecting all those parts of the machinery that are difficult or expensive to replace. The pinions (f) consist of forged steel and their pitch circles have a diameter of 2 ft. 6⅛ in. Each pinion is provided with two separately cut tooth gears, one cutting lagging behind the other by half a tooth pitch. The gearing is designed to ensure that several teeth will always be engaged at the same time, thus warranting steady and silent working of the gear. The pinions are supported in the bearing chocks of the spindle housings B which stand up right on the foundations, and are carried in broad strong pedestal brackets which are fastened securely to the foundations. The housings B are of the totally enclosed, top lidded, easily accessible type. The grease-lubricated bearings are lined with white metal (antifriction metal); they are leak-proof at the sides to prevent grease from oozing out. The wobblers of the pinions and those of the rolls are connected by spindles (g) with Kennedy sockets. The spindle bearings are contained in a common bearing housing D consisting of two cast-iron pedestals. The bearing of the lower spindle rests on an elastic plate bridge, whereas the middle and top spindle bearings are held in position by balanced levers.

Roll Adjustment

The distance between the rolls is adjusted by shifting the top and middle rolls (b) and (c) respectively. The middle roll is balanced by weights (h) and raised and lowered by positive gearing with lifting table F. Adjusting and balancing the top roll (c) is performed by an electric adjusting and balancing device as illustrated in Fig. 7. To be able to regulate top roll (a) and chock (b), together with breaker (c), up and down in housing (f) with the aid of pressure spindle (d) and pressure nut (e), the balancing weights must keep roll (a) and its accessories (b) and (c) in positive and permanent connection with pressure spindle (d), even when there is no bloom between the rolls. To this end motor (g) (i in Fig. 3) drives square-head (k) of pressure spindle (d) through worm (h) and worm-wheel (i), screwing spindle (d) either up or down according to the direction in which the motor is rotating. At the same time the hollow, threaded spindle (l) mounted rigidly on worm-wheel (i) and possessing a thread of the same pitch as pressure spindle (d), only in the reverse direction, is screwed forward through cross-head (m), from which chock (b) is suspended by means of springs (n) and rods (o). The downward motion of the top roll (a) is therefore caused by pressure spindle (d), while its upward motion is obtained through the hollow spindle (l), cross-head (m), and tension rods (o). This method of balancing by weights has given excellent satisfaction in practice having been attached to 120 rolling mills of various types and sizes. When compared with the hydraulic balancing system of former practice, which method was also perfectly reliable, balancing by weights has the great additional advantage of reducing the first cost, because it does away with the auxiliary hydraulic plant, pumps, accumulator, and all accessory details. Hydraulic pressure plants moreover possess many drawbacks inasmuch as their pipe systems and stuffing boxes always show an unpleasant tendency to leak, especially in winter when the water often freezes even though the utmost care is taken in their manufacture. The electric adjusting and balancing device is totally enclosed and all the gears are thus protected against dust. All the gears are easily accessible. Finally, the two housing standards are exactly similar, thus only one spare standard has to be kept in reserve for emergencies.

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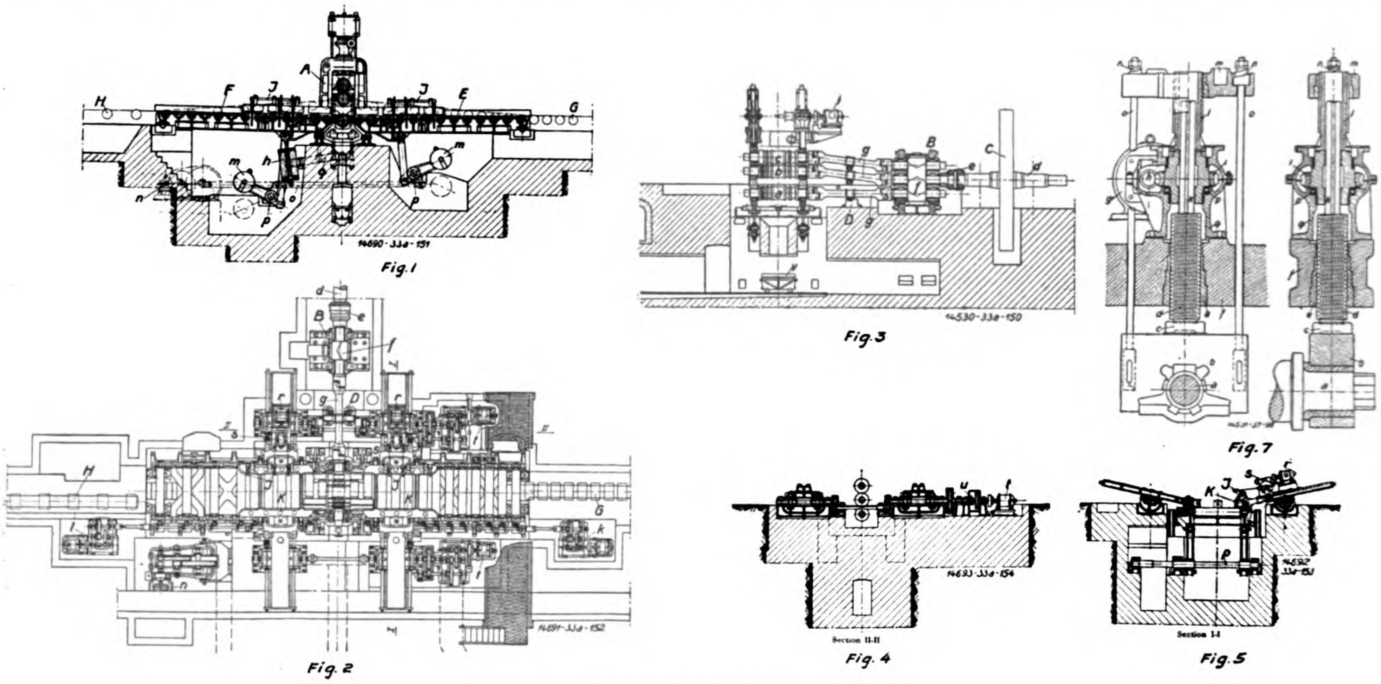
*Demag News, July, 1927



Various sectional views of blooming mill.

The pressure spindle (d) is completely balanced and its square-head (k) slides in the body of the worm wheel. The dead weight of the top roll (a) is transmitted to a worm wheel (i) via chock (b), suspension rods (o), springs (n), cross-head (m), and the hollow spindle (l). To facilitate its motion, the worm wheel is supported on a ball bearing (p), whence the pressure is transmitted to the housing (f) through hood (q). The upper and lower spindles are always locked against one another in the treading. The pressure spindle and the chock therefore always perform the same motion, and the top roll is prevented from jumping when the bloom enters the rolls. The heavy shocks arising through the bloom entering the rolls, which increase considerably as the pressure spindle gradually gets worn, are thus completely avoided. Worm (h) and worm wheel (i) partly work in a leak-proof oil-bath contained in the housing hood q.

The worms of both housings are coupled by a divided shaft with a sliding clutch; the motor drives them through a disc coupling (Fig. 3). In adjusting the pressure spindles one of the plates of the disc coupling is used as a rake disc. The 60 bhp. motor can therefore be controlled by an electro-magnetic brake which allows convenient and accurate adjustment. The worm shaft (h) operates two indicating hands, one of which indicates the hundreds, while the other one shows the tens and units. The correct distance in mm. either between the middle and top rolls or the middle and bottom rolls can thus be immediately ascertained, at any moment, by a glance at the two indicators. Breakers (c in Fig. 7) are provided to protect the housings and roll against breaking. They are of cast iron and designed to break with certainty before any other part of the housing gets overloaded.

Lifting Tables

The lifting table plant serves to raise and lower the blooms to and from the pass between the top and middle rolls before and after the reverse pass. It comprises two lifting tables E and F placed respectively in front and in the rear of the mill, each of them having a length of about 29 ft. 6$\frac{3}{8}$ in. The lateral beams of the lifting tables support 10 and 13 steel rollers respectively of 1 ft. 3$\frac{3}{4}$ in. diam. and 7 ft. 4$\frac{9}{16}$ in. length; the lateral beams are pivoted on continuous shafts resting in powerful pedestals. The table rollers are driven by two 40 bhp. electric motors (k) and (l), one for each table (Fig. 2). Both motors have double spur-wheel gears and each complete motor and gear is mounted on a common base-plate. From the gear a jointed spindle transmits the power to a shaft running in bearings on the frame of the table; the shaft drives the individual rollers by bevel gears. All gear wheels are of steel and work in oil-baths in leak-proof cast-iron boxes with sight holes covered by oil-tight lids. The lifting tables are balanced by weights (m), but a certain amount of excess momentum remains available when the tables are in their highest and lowest positions; this excess momentum assists the driving motor (n) in starting up. When the table is in its lowest position, the excess momentum is produced by the counter-weight, whereas the weight of the table acts when the latter is in its highest position. The 100 bhp. motor (n) has an enclosed double gearing and, through two overhung cranks, connecting rods (o), and levers, drives two intermediate shafts (p) carried by bearings in the foundations. Each of the two intermeidate shafts (p) carries two rocking levers with the table counter-weights (m), which control the rods lifting the tables. The coupling between the electric motor and the spur-wheel gear is equipped with an electric magnetic brake. The middle roll (b) is raised and lowered by the lifting table F in the rear of the three-high blooming mill. Two spring-loaded, weight balanced connecting rods are linked to table F. They act upon cross-beams through a rocking lever q with movable fulcrum and guide. Each of the cross-beams is linked to the chocks of the middle roll (b) by a pair of rods. At the points where the rods are linked to the cross-beams, buffer springs are provided in order to enable the whole rod system to be elastic.

Electrical Manipulators

Electrically operated bloom tilters and bloom shifters which add materially towards speedy work at the mill, are installed both in the live roller gear bed G of the lifting table E and in the discharge roller gear bed H of lifting table F. In this special design the tilters and shifters offer the further advantage of enabling the rolled blooms to reach the three-high mill with rolls of 1 ft. 11⅝ in. diam. in a sufficiently hot condition after leaving the previous mill via the discharge roller gear bed H. The 1 ft. 11⅝ in. three-high mill forms the direct continuation of the three-high mill under discussion. It is thus possible to continue the rolling of the blooms without having to reheat them, while the housings and shears experience less wear and tear. Finally, the speedy and efficient production of high-class finished plates is obtained economically by this mill.

The tilter J serves to turn the blooms and billets over after each pass, while the shifter fences K push the bloom in front of the next pass. The tilting and shifting device consists of two frames, each of which carries a guide plate forged of steel; one of the frames also carries the tilter with three tilting levers keyed to a common shaft. The tips of the tilters come up between the rollers of the lifting table, seize the lower edge of the bloom, lift it and turn it over, whereupon the bloom is pushed into its new position in front of the next pass by shifting the frame. The tilting levers are operated by two 20 bhp. electric motors (r) with worm gears (s), while two 40 bhp. electric motors (t) with spur-wheel gears (u) (Figs. 4 and 5) serve to drive the shifters.

The entire rolling mill is electrically driven. The complete absence of steam as well as pneumatic and hydraulic pressure as a driving factor contributes materially towards rendering the construction and working of the mill so simple and reliable. All the gears are protected by dust and oil-proof casings. They are all located at the side of the train and above the level of the floor, and are therefore easily accessible. The lifting gears of the tables and the bearings of the lifting shafts alone are situated below the level of the floor, but these too are placed at the side of the main canals so as to prevent trouble arising through mill cinders or scale dropping onto them. The main canal is thus left entirely clear and it can therefore be used for running cinder and scale lorries (v) below the mill. These lorries move on rails and are finally taken to an elevator shaft for removal.

The economical working of this three-high blooming mill is chiefly due to the extraordinary simplicity of its driving gear. Reversing blooming mills always require reversible prime movers for driving them because the rotation of the rolls, and, consequently, of the prime movers, must be reversed after each pass. In order to achieve a high degree of control it is imperative for the reversing gears that the fly-wheel momentum be as small as possible, but nevertheless the discharge of work from a reversing mill fluctuates far more rapidly and frequently than in continuous work. With the mill herein described the fluctuations of load can be neutralized to a very great extent by means of fly-wheels. If steam engine drive is employed, the fly-wheel is usually mounted on the engine shaft, whereas with electric motors it is placed on a special intermediate shaft. Reversible prime movers are also much more expensive in first cost than continuous mills. If steam engines are used, a reversible twin tandem engine must be substituted for the ordinary una-flow engine. In the case of electric drive Ilgner transformers are necessary in order to obtain sufficiently rapid acceleration and retarding of the reversible d.c. motors. The Ilgner transformer consists of a control motor working at uniform load and designed for the current available in the supply system. It further comprises one or several control generators supplying d.c. of varying tension for the motor driving the rolls. High speed fly-wheels on the shafts of these machines serve to neutralize fluctuations in the loads. Instead of a single roll motor working continuously in one direction only, at least two motors and one or several starting generators will thus be needed. Together with all the necessary accessories, these would evidently work out much dearer in the aggregate than the one motor working continuously in one direction.

Westinghouse Awards War Memorial Scholarships

Two Pittsburgh and two New York youths received awards in the 1927 War Memorial Scholarships of the Westinghouse Electric & Mfg. Company. The scholarships, established in memory of the Westinghouse employes who lost their lives in the World War, carry a fund of $500 a year and are good for a period of four years.

The winners in the 1927 contest were: H. L. Bunker, Jr., son of H. L. Bunker, rate setter, East Pittsburgh works. Young Mr. Bunker will attend Carnegie Institute of Technology; P. J. Glaister, tester, East Pittsburgh works, who will attend Cornell University; M. T. Ayres, son of M. C. Ayres, foreman of dial markers, Newark works. Mr. Ayers will attend the Massachusetts Institute of Technology, A. L. Kime, the fourth winner, is the son of R. R. Kime, salesman, New York office. Mr. Kime will attend Princeton University.

Over 52 were entered in the contest. Vice Presidents L. A. Osborne and Walter Cary and Acting Vice President T. P. Gaylord were the deciding committee.

Thirty-two students have received scholarships since its beginning. Eighteen of these have graduated, and eleven are still in school.

Wheeling Steel Corporation's New Furnace

Blast Furnace Features Novel Development in Gas Wasting—Capacity Equal to Production of Largest Furnaces—Bells Operated by Electric Hoists

MARKING another step in the progress of its work in balancing and modernizing its plants for greater efficiency, the Wheeling Steel Corporation, recently completed and placed in operation its new No. 2 blast furnace at the Steubenville, Ohio, works. The new stack is equipped with the most modern and efficient labor-saving devices and in productive capacity is equal to any of the larger blast furnaces of today.

The furnace is located on the site formerly occupied by a smaller stack which was dismantled and scrapped. Originally built in 1903, the old furnace was 90 ft. in height and its diameter was 20 ft. at the bosh and 16 ft. at the hearth. All the existing plant units which were unsuitable or lacking in capacity for operation in conjunction with the larger stack were modernized or replaced. The improvements include gas cleaning equipment of a new type, the installation of an electrically operated skip hoist, electric bell hoists of improved design, dust catcher, gas mains, cast house, remodeling of bins and new scale cars. The furnace is 92 ft. in height, the diameter of the hearth is 21 ft. 6 in., the diameter of the bosh 25 ft., the bosh angle 80 deg. 4 min. 25 sec., and the diameter at the stock line 17 ft. 5 in.

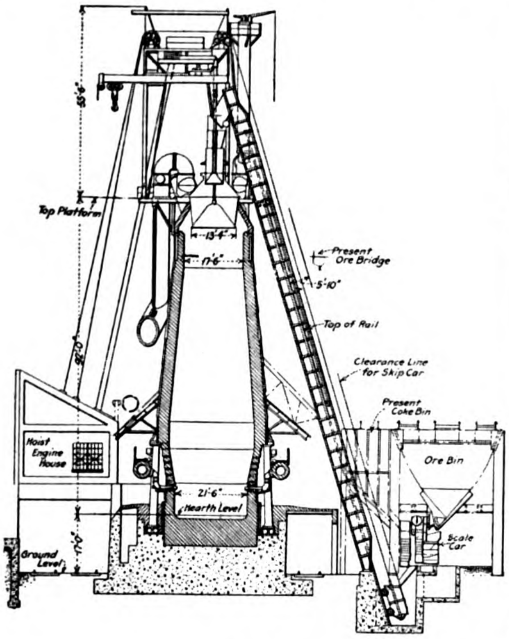


Fig. 1

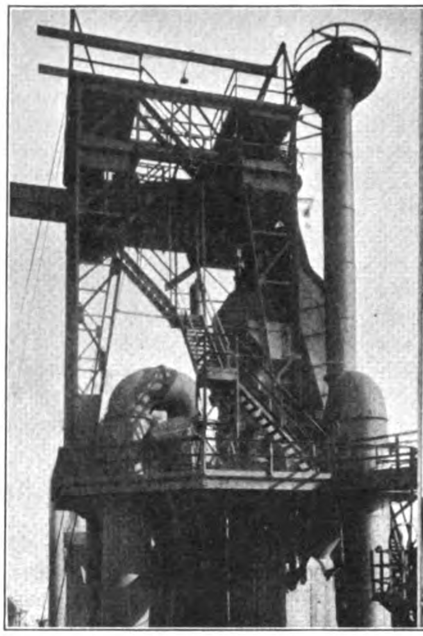


Fig. 2

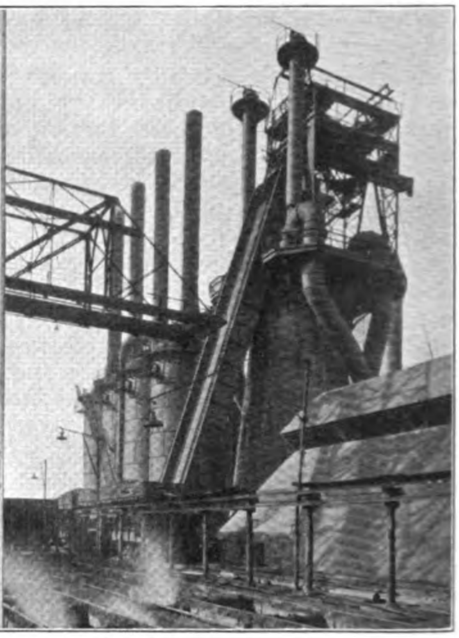


Fig. 3

FIG. 1—Sectional view of furnace. FIG. 2—Top platform of new stack showing low type baffled downcomers. Attention is called to the absence of the usual furnace top congestion. FIG. 3—General view of new furnace from skip side.

There are 16 tuyeres fitted, and the copper cooling plates go as high as the mantle. A Brosius automatic mud gun was installed for plugging the iron notch. Eight cast iron columns support the furnace stack, the shell of which is of 1-in., ⅞-in. and ¾-in. plate. The furnace top equipment includes a steel plate gas seal, a McKee revolving distributor with self-contained worm and gear drive and automatic gage rod. A 30-ton trolley is provided for raising and lowering the large bell and hopper.

Rigidly keyed to its rod, the large bell is 13 ft. 4 in. in diameter. The small bell, 5 ft. 6 in. in diameter, is suspended from a rod made of double extra heavy steel pipe with removable wearing rings.

Electrically Operated Bell Hoists

Bells are lowered and raised by two electrically operated bell hoists of the Morrison type. Each hoist is equipped with an equalizer, to which the main operating cable, leading from the end of the bell beam, is attached. Extending from the equalizer two ropes are carried to pins on the ends of levers fulcrumed on either side of a large gear, but connected to the gear through a spring barrel trunnion, the spring being compressed when the bell is seated. When the hoist starts operating, the gear makes approximately one revolution, the bell lowers and raises, and when the spring has been compressed sufficiently to give the desired sealing pressure between the bell and hopper, a limit switch stops the motor and sets the brake. The bell hoists require little power, as the motor is overhauled when the bell is lowered by the burden and the unbalanced weight of the bell.

The furnace is also equipped with a Berg-Proudfoot gage rod, which operates automatically at desired intervals, through a motor and hoist. The height of the stock is indicated after each test and all tests are permanently recorded on a Bristol chart recorder.

For changing the furnace, an Otis electric hoist and two 160 cu. ft. skip cars were provided. The cars are equipped with roller bearings and manganese steel wheels and are lined with high-carbon steel wearing plates. The double-track skip bridge, of the plate girder type, is supported from the furnace top platform. Deck plates the entire length of the bridge prevent material from falling through.

In the stock house, two additional ore bins were provided and the existing bins were equipped with new bottoms. For weighing the ore and stone and transferring these materials from the bins to the skip pit a new 300 cu. ft. larry car was supplied. The car is of the double-hopper type, electrically operated, and is equipped with air operated gates, brakes and dial scale.

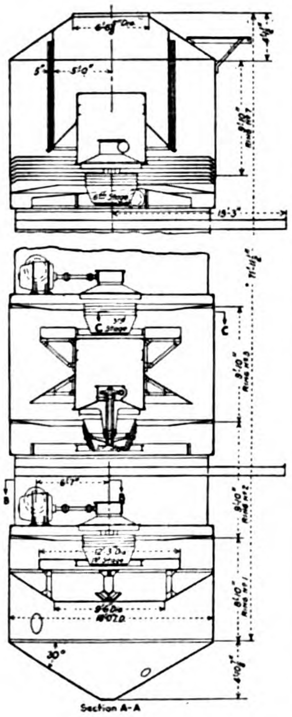


Fig. 4

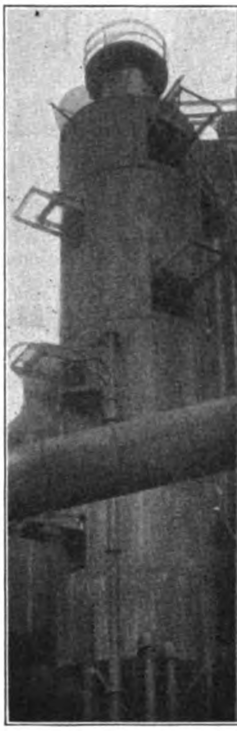


Fig. 5

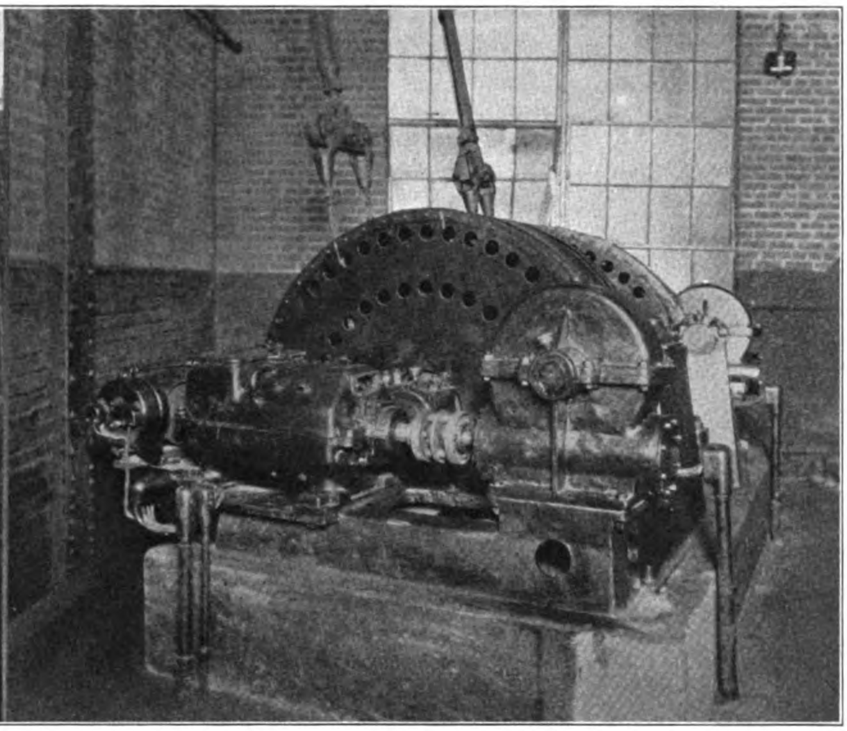


Fig. 6

FIG. 4—Cross section of six-stage gas washer. FIG. 5—New type of McKee six-stage gas washer, each stage being a separate unit. FIG. 6—Morrison type electric bell hoists.

Operation of Gas Washer

Designed by Arthur G. McKee & Company, the gas washer consists of a cylindrical steel shell 72 ft. high and 18 ft. in diameter, divided into six compartments or stages. Each stage comprises a complete separate gas washer equipped with individual rotor unit and drive mechanism. The drive consists of a 20-hp. motor connected through a flexible coupling and shaft to a worm and gear, which drives the main shaft of the motor. This drive mechanism is located in a tunnel, isolating it from the washing compartment proper, and making the drive readily accessible for inspection and oiling. The main rotor shaft extends through a housing casting into the lower portion of the compartment, and at the lower end of this shaft is attached a multiple cone rotor which hangs over and into a circular steel pan.

The rotor pumps water from this supply pan and diffuses it into a dense, fine spray. To insure against the formation of mist, louvers are provided around the inside of the washer shell, to prevent splash from the impingment of water against the shell.

Gas is admitted to the washer just above the waterline of the bottom compartment and passes upward through the spray of each successive stage. Baffle plates are provided throughout the interior of the washer to govern the flow of the gas and to distribute it so as to get the maximum efficiency from the various sprays. A curtain wall, made up of a series of vertical channels, is installed in the top cone of the washer, to baffle further the flow of gas and thus remove entrained moisture.

The water requirement of the washer is kept to a minimum by the arrangement for recirculation of water. The overflow from each stage, except the bottom, discharges to and is resprayed in the stage immediately beneath. The third and fourth stages are both arranged so that it is possible to discharge only a portion of their overflow water to the next lower stage, the remainder being sufficiently low in dust content to pass directly to the sewer. The sewer outlets, however, may be by-passed and the water adjusted as desired.

As the top stage of the washer pumps only cool, clean water, a low temperature differential between inlet water and outgoing gas is maintained, with consequent low moisture content in the gas. All units of the washer are interchangeable, and operate independently of each other. This makes it possible to shut off one or more units without disturbing the operations of the rest of the washer. Gas mains to and from the washer are provided with Kling-type goggle valves with remote controls.

All of the work in connection with the new furnace, with the exception of cast house alterations and furnace brickwork, was executed under one contract. This included designing, furnishing of equipment, and field erection, by Arthur G. McKee & Companw, engineers and contractors, Cleveland.

Centrifugal Pump Efficiency Guarantee

The Author Contends That the Purchaser of Pumps Should Take into Consideration the Size of the Suction and Discharge Nozzles in Comparing Pump Efficiencies

By GEORGE H. GIBSON*

THE efficiency of a machine which has for its purpose the transfer or transformation of energy is ordinarily defined as the ratio of the energy applied to turning the shaft, while the energy output is calculated as the volume of fluid handled multiplied by the increase in pressure generated, or as the weight of fluid multiplied by the head pumped against. The total mechanical energy of a fluid, however, includes pressure head, elevation head and velocity head, all of which items must be taken into account.

The gain in pressure is readily measured by means of pressure gauges connected to the inlet and outlet nozzles, respectively. Any difference between the elevations of the pressure responsive parts of the two pressure gauges must be taken into account as elevation head. This is easily measured, or can be eliminated from the calculation by locating the two gauges at the same level.

The remaining item, velocity head, is sometimes overlooked and sometimes misunderstood by the pump user, and is the subject of the present discussion. Velocity head is the vertical distance in which a freely falling body would gain the velocity being considered, and is equal numerically to the velocity in feet per second squared, divided by twice the acceleration of gravity in feet per second, or in algebraical symbols,

$$\frac{V^2}{2g}.$$

The velocity of the fluid as it enters the suction nozzle or leaves the discharge nozzle of a centrifugal pump is readily calculated by dividing the flow in cubic feet per second by the cross-sectional flow area in square feet. If the areas of the suction and discharge nozzles are equal, there is no correction for velocity head, but if one is larger than the other, the difference in velocity head is added to, or subtracted from, the pressure head developed by the pump, accordingly as the discharge nozzle is smaller or larger, respectively, than the suction nozzle. The rule given in the "Standards of the Hydraulic Society" reads:

> "If the discharge pipe is of smaller diameter than the suction pipe, which is often the case, then it will be necessary to add to the total head, as shown by the gauges, the difference in velocity head between that of the discharge and that of the suction pipe at the points where gauges are connected. If the discharge pipe is larger than the suction pipe, the difference in velocity head must be subtracted from the total head."

From point of view of energy transferred to the water in the pump, the theory of this rule is entirely correct, but it can lead to considerable error in evaluating the practical utility of a pump. The piping connections should also be considered, as will appear from the following example.

Comparison of Pumps

Suppose that bids are asked on a pump of 18 in. nominal size to deliver 9,000 gals. per min. against 35 ft. head, and that one manufacturer, figuring on a pump with 18 in. suction nozzle and 18 in. discharge nozzle, guarantees 82 per cent efficiency, while another manufacturer offering a pump having an 18 in. suction nozzle and a 16 in. discharge nozzle guarantees 82.5 per cent efficiency. Which is the better pump, other things being equal? It is assumed that on test each pump will show exactly the efficiency guaranteed. The pump credited with the higher efficiency, however, gets credit for its efficiency by virtue of a velocity head correction of

$$\frac{(14.4)^2}{(64.4)} - \frac{(11.4)^2}{(64.4)} = 1.2 \text{ ft.},$$

11.4 ft. per sec. being the velocity in the suction nozzle and 14.4 ft. per sec. the velocity in the discharge nozzle, and the question before us is, does the customer receive the full benefit of this velocity head?

If there is space enough to install a straight 16 in. x 18 in. increaser, from 60 to 70 per cent of the velocity of the water as it leaves the pump may be converted into useful pressure head. It will not in general do to have the entire discharge piping of 16 in. diameter, as that would lead to excessive pipe friction, in fact in practically all cases it should be larger than 18 in., 30 per cent of 1.2 ft. is .36 ft., so that there will still be a net loss of about 1 per cent of the total head. and the overall efficiency will be 99 per cent of 82.5, or only 81.67 per cent, as compared with the 82 per cent guaranteed for the pump having the 18 in. discharge nozzle.

Manner of Installing Pump

In probably 95 cases out of 100, moreover, the pump will be installed with the discharge flange bolted directly to an elbow to connect with a pipe extending vertically upward to the ceiling or downward through the floor. The friction of a 90 deg. ell is commonly figured as equal to that of 50 ft. of straight pipe, on which basis, the pump with the 18 in. discharge nozzle will have a loss through the elbow of 1.63 ft., while the pump with the 16 in. discharge nozzle will have a loss through the elbow of 2.85 ft. The loss with a 16 x 18 in. increasing ell would be almost as great, because there would be practically no conversion of velocity to pressure in the elbow. There is accordingly an increased loss due to the use of the 16 in. discharge nozzle of 2.85 ft. — 1.63 ft. = 1.22 ft., or 3.48 per cent of the total head developed. Based upon readings taken at the outlet of the ell, the pump having the 18 in. discharge nozzle has a useful efficiency of

$$\frac{35 - 1.63}{35} \times .82 = 78 \text{ per cent},$$

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*Consulting engineer, New York City.

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while the pump with the 16 in. discharge nozzle has a useful efficiency of only

$$\frac{35 - 2.85}{35} \times 82.5 = 75.7 \text{ per cent.}$$

The customer similarly pays an excessive price for a small discharge nozzle where a check valve is bolted directly to the pump flange, as is frequently done. At high velocities, friction losses through check valves are considerable. The friction through a 16 in. valve at 14.4 per sec. velocity may, depending upon design, be as much as 6.1 ft., and through an 18 in. valve at 11.4 ft. per sec. velocity, 3.8 ft., or an additional loss through the 16 in. valve of 6.1 — 3.8 = 2.3 ft. Therefore, based upon the head remaining at the discharge from the check valve, the 18 in. discharge nozzle pump will show an efficiency of

$$\frac{35 - 3.8}{35} \times .82 = 73.1 \text{ per cent,}$$

while the 16 in. discharge nozzle pump will show

$$\frac{35 - 6.1}{35} \times 82.5 = 68.2 \text{ per cent}$$

or about 7 per cent lower useful output than the 18 in. discharge nozzle pump.

In other words, the customer should consider the complete installation, including the piping arrangement which will be used with the pump, when comparing efficiencies, and he should bear in mind that a pump having the proper size of nozzle may give a greater useful effect, even though its guaranteed efficiency is lower. This applies particularly to low head pumps, where the velocity head constitutes an appreciable part of the total head.

As the velocity in the pump volute is always much higher than in the discharge nozzle, one of the problems of the pump designer is to convert this high velocity into pressure as efficiently as possible, but it is easier for him to leave the velocity high, clear up to the discharge nozzle, especially if he can persuade the user to give him credit for the entire gain in velocity head between suction and discharge nozzles.

The better showing made by the pump having a small discharge nozzle will be more than offset by loss in the piping unless an efficient straight increaser is put in between the pump discharge flange and the pipe line. Unless this could be done, the pump with 18 in. discharge nozzle in the above example would be much preferable to the pump with 16 in. discharge nozzle.

In any event, a pump which has a discharge nozzle smaller than the suction nozzle should not be given full credit for velocity head in comparing it with a pump having both nozzles of the same size, since it is impossible to convert 100 per cent of the velocity into pressure, even with the best piping layout. In most installations, as a matter of fact, no effort is made to obtain efficient conversion of velocity head into pressure.

Institute of Technology Establishes New Field Station

Through Mr. C. L. Edgar, president, and Mr. R. E. Dillon, superintendent of the Generating Department of the Edison Electric Illuminating Company of Boston, arrangements have been completed whereby the students of the course in Fuel and Gas Engineering of the Massachusetts Institute of Technology will do field work and testing at the Edgar Station of the Edison Company.

This course is intended to train graduate engineers in the theory and practice of fuel utilization, gas manufacture, and power generation. The work consists of one academic year of graduate study at the institute, followed by six months' field work.

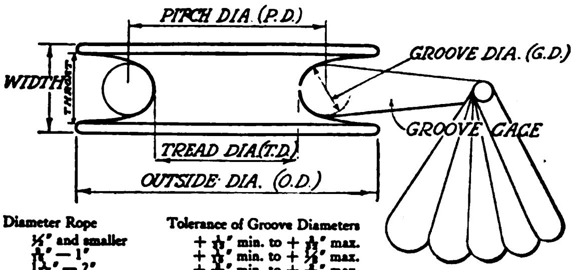
Do the Sheaves Fit the Rope?

By Walter Voigtlander*

There is perhaps no single element that can be more detrimental to wire rope than an improperly fitted sheave. A pinching sheave, for instance, will do more damage to a wire rope in one hour than a properly grooved sheave could in an entire week or more. Or a sheave with too soft a tread will increase abrasion and grinding action to an extent that will cause premature breaking of the outer wires and loss of rope strength. Because of these facts and because sheaves are cheaper than good wire rope, it may be well to look to the sheave and auxiliary equipment if it is felt that the life and service being received from present rope is not all that it should be.

Engineers and operators some time overlook the fact that by the time it becomes necessary to install a new rope the old sheave will have become worn to such an extent that it will cause serious loss to the service of the new rope. Invariably excessive wear to the outer wires can be traced to the abrasive action of worn or too soft sheave treads.

Proper Groove Diameters for Various Size Ropes



Diameter Rope	Tolerance of Groove Diameters
¾" and smaller	+ 1/32" min. to + 1/16" max.
13/16" — 1"	+ 1/16" min. to + ⅛" max.
1 1/16" — 2"	+ 3/32" min. to + 3/16" max.
Over 2"	+ ⅛" min. to + ¼" max.

When installing a new rope, therefore, it is economy to gauge both the rope and the grooves of all sheaves and drums. If the groove diameter of any sheave is less than the actual callipered rope diameter, decreased service is bound to result.

One of the simplest and most accurate methods for gauging sheave treads is through the use of a groove gauge as indicated by the accompanying illustration. If this device is used with care, and if the tolerances given in the accompanying table (which have been worked out in accordance with long experience) are strictly adhered to, there may be reason to expect longer and more satisfactory rope service.

At the time such attention is given sheaves it is well, also, to check up on alignment. Poor alignment will cause considerable wear to both rope and sheaves. Particularly in high-speed work is it necessary to maintain proper alignment of all equipment and to balance all sheaves.

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*Rope Engineer, American Cable Company.

The POWER PLANT

Waste Heat Boiler Application

A Concise Recital of the Economical and Practical Aspects Entering into the Selection and Installation of Boilers for the Recovery of Waste Heat

By J. B. CRANE*

ALTHOUGH a large majority of steam boilers are fuel fired, waste heat applications hold a place of increasing importance in the boiler industry. The use of devices to recover waste heat from gases is not new. The amount of money for capital investment is always limited and other things being equal, will be invested where it can bring in the maximum returns.

In central station work, the maximum returns, until recently were obtainable by installing newer and more efficient turbines and more modern stokers or pulverized coal under the boilers. These have now approached their maximum limits and the central station engineers are devoting their attention to the recovery of heat in waste gases discharged from the boiler, with the installation of economizers, or air preheaters or both, and by working the other end of the cycle by going to higher pressures and to as high temperatures as modern materials will stand.

In industrial plants, the maximum returns were formerly obtainable by revamping the mill equipment, by the installation of more modern drive on tools, and by the installation of more modern equipment in the furnace house and power house.

Many industrial plants have been modernized in the past few years, and the recovery of heat in waste gases presents itself as the next point of attack.

Here again the law of maximum returns enters in and while each individual case requires its own study, a typical case is here presented (see Fig. 1) and the following assumptions are made

Waste gases	90,000 lb. per hour
Temperature of gases at exit of furnace	1,100 deg. F.
Feed Water	212 deg. F.
Pressure	250 lb. gauge

The gases cannot be discharged from the boiler below the temperature of the steam and water in the boiler. In this case the water temperature is 406 deg. F. represented by a straight line at the bottom of the curve. Theoretically, we can install enough heating surface to reach this line at infinity. It will be noted that to reduce the temperature of the escaping gases to 600 deg., 4,200 sq. ft. of heating surface is required. To reduce it another 100 deg., 2,450 sq. ft. additional surface is required. To reduce it to 450 deg. or 50 deg. more, 2,450 sq. ft. is required, and to reduce it to 425 deg. or another 25 deg., 2,900 sq. ft. additional is necessary. It then becomes a matter of calculation as to whether the last 25 or 50 deg. will return sufficient money on the investment to be worth while.

Many worthy projects have been turned down because the cost has been estimated on securing the last Btu. If the proposal had been made upon the basis of maximum return, there would be many more installations in the country today.

This is shown more clearly in the following table:

Exit temp.	Sq. ft. heating surface	Assumed cost	Lbs. steam per hour	Annual value 6000 hours, 40c per 1000 lbs.	Return on investment
600	4,200	$21,000	10,260	$24,600	117%
500	6,650	33,250	12,320	29 600	89%
450	9,100	45,500	13,335	32,000	70%
425	12,000	60,000	13,851	33,200	55%

(The above table is based on an installation cost of $5.00 per sq. ft. of heating surface and steam estimated as worth 40 cents per 1,000 lbs.)

It will be noted that the first increment of investment shows a return of $24,600 on the investment of $21,000, or 117 per cent return.

The next increment shows a return of $5,000 on an added investment of $12,250, or 41 per cent return.

The third increment returns $2,400 on an added investment of $12,250, or 19½ per cent return.

The fourth increment returns only $1,200 on an added investment of $14,500, or only 8¼ per cent on the investment.

In this particular case, the operating cost will be in the neighborhood of $6,000 per year and will be charged against the first increment, and the additional increment would require very little for operating cost. We then draw a curve showing $18,600 or 88.5 per cent as the return on the first increment and passing through the return shown for the other increments (see Fig. 2). We would then pick the heating surface which showed the return asked for by the financial department. Some plants require a return on the investment of 50 per cent, others 30 per cent and still others, where money is plentiful, will make an investment of this kind on a return of 20 per cent.

Settings for Waste Heat Boilers

The draft in waste heat boilers is higher than with fuel fired boilers on account of the necessity of providing for draft at the end of the furnace to which the boiler is connected. This varies from .6 of an in. of water with cement kilns to as high as 2 in. of water with open-hearth furnaces. Also, the velocity of gases through the boiler is higher so that the suction in the boiler proper may be 2 to 4 in., instead of 1 to 2 in. This was not recognized with early installations and these gave poor results on account of excessive air infiltration. It is now customary to furnish a steel casing or to cover the brickwork with a bitumastic preparation. The latter costs about one-tenth of the steel casing, is just as effective as far as sealing against air leaks and when properly applied presents a good appearance. Cracks show immediately and can be repaired at once. Two 1,200-hp. boilers have been in operation for two years using this type of construction and the infiltration is only 5 per cent between inlet of the boiler and stack through boiler, economizer, fan, and all flue connections. This is checked daily by Orsat readings and has required very little attention to keep in this condition; the operating engineer doing all of this work.

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*Engineer, Combustion Engineering Corporation.

It is also desirable to keep radiation losses to a minimum and curves are shown illustrating losses with different constructions.

Fig. 3 shows the Btu. loss per in. of thickness per hour per sq. ft. of exposed surface.

It will be noted that the characteristics of all fire brick are not the same. On waste heat work No. 2 quality is generally satisfactory if the temperature of entering gases does not exceed 1,200 deg. F.

Fig. 4 shows heat transmission of typical insulating brick, such as Sil-o-cel, Quigley, Armstrong, etc.

The following formula gives a method of comparing different wall constructions.

$$\text{Btu. loss} = (T - t) \times \frac{1}{\frac{FB}{R} + \frac{CB}{R} + \frac{IB}{R}}$$

T = Inside boiler temperature.
t = Outside or room temperature.
FB = Thickness of fire brick in inches.
CB = Thickness of common brick in inches.
IB = Thickness of insulating brick in inches.
R = Btu. transfer rate shown in Figs. 3 and 4.

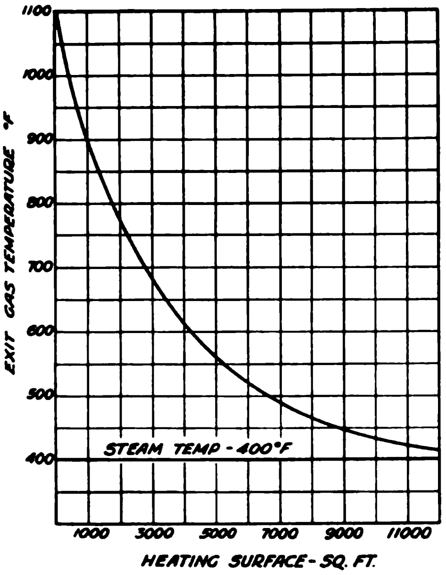

Fig. 1

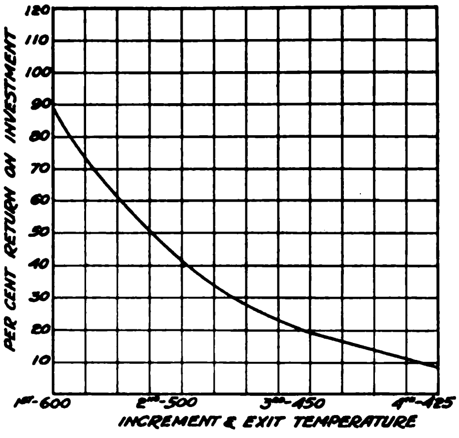

Fig. 2

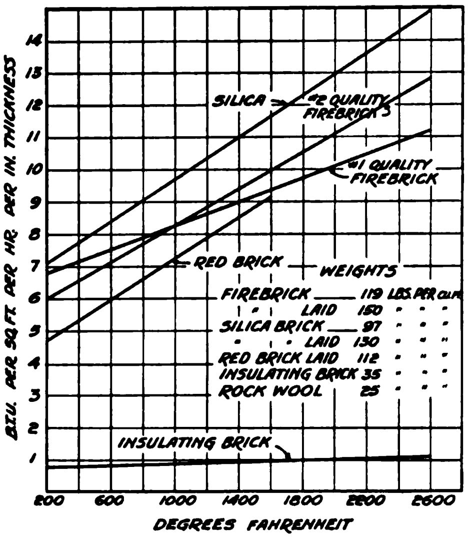

Fig. 3

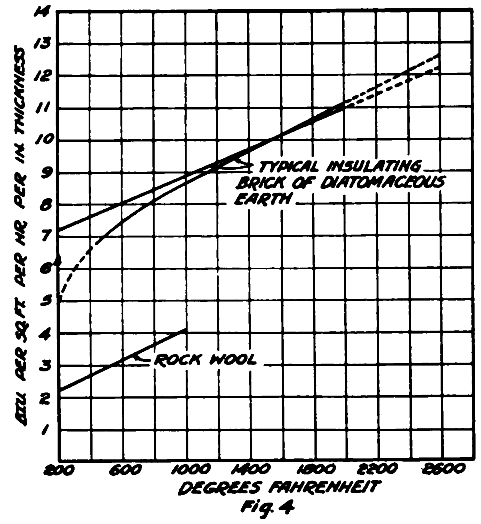

Fig. 4

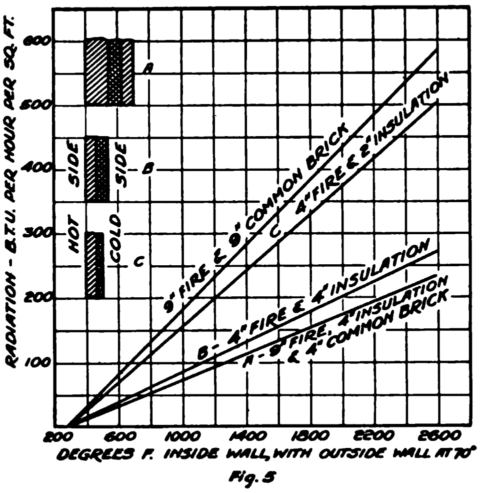

Fig. 5

Fig. 5 shows the result of applying the above curves and formula to different wall constructions. It will be noted that 4 in. of fire brick and 2 in. of insulating brick makes a better wall than ordinary wall construction of 9 in. of fire brick and 9 in. of common brick. This thinner wall would require steel casing with the brick work fastened to the casing for mechanical stability of the wall. A wall construction which has proved very satisfactory for waste heat

(Continued on page 453)

Tests to Determine the Extent of Priming*

While the Tests Were Run Primarily to Determine the Action of Saline Waters, the Experiments and Conclusions Are of Value For All Waters

By A. F. JOSEPH and J. S. HANCOCK

THE investigations described in this paper were designed to ascertain the causes and prevention of priming in locomotive boilers, this being a particularly important problem in those parts of the world where the supply of water for locomotive steam raising is not only of very bad quality, but also limited in quantity. In the Sudan it is not uncommon to be obliged to use water containing up to 2,000 parts of dissolved solids per 1,000,000 (140 grains per gal.), and, owing to shortage of supplies, blowing down can only be done when really necessary. Under these conditions, the concentration of solids in the boiler rises to a degree at which priming takes place, which shows itself in bad cases by the carrying over to the cylinders, through the regulator valve and superheater elements, of a smaller or larger proportion of water mixed with the steam. At the same time, water is carried with the steam to the vacuum ejector, causing the vacuum to fall and the train brakes to drag. In certain cases also the gauge-glass is filled completely with a mixture of water and steam bubbles, so that the driver is unable to judge the true water level. Priming not only causes a wastage of fuel—since the hot boiler water carried over does no useful work—but also results in the blocking of superheater tubes by the deposition of dissolved and suspended solids carried over by the water, destruction of the lubricating value of the oil in the cylinders with consequent overheating, corrosion of steam pipes, valves, cylinders, etc., and a shortening of the time an engine is in use owing to the necessity of its being washed out more frequently.

Ejection of water and the appearance of bubbles in the gauge glass are the only external signs of priming which have been observed in our experience, but various writers have described the following phenomena which may take place inside the boiler:

(a) The formation upon the water surface of a foam consisting of bubbles of steam enclosed by films of boiler water. This foam may vary in thickness from a layer of single bubbles to a mass which fills the entire steam space. When the latter is the case, the steam and boiler water are both carried through to the cylinders and the phenomenon of priming are observed.

(b) The projection of droplets or slugs of water into the steam space, some being entrapped by the escaping steam.

(c) The formation within the boiler water of a vast number of small steam bubbles, which, rising rapidly upward into the steam space, carry much of the boiler water with them.

(d) The phenomenon of "bumping" is commonly referred to as a less frequent variety of "priming," and may be described as an explosive or intermittent boiling caused by superheating of the boiler water.

We have not observed (b), (c), or (d), and shall in this paper use the term priming to mean the ejection of water with the steam, and the subsidiary phenomenon of bubbling in the gauge glass.

The cause to which priming has been attributed all depend on some impurity in the boiler or boiler water: these include oil or grease, soap, scale, suspended matter, and dissolved solids. Whilst it is generally recognized that the type of boiler and conditions under which it is worked may greatly influence priming, no systematic study of these factors seems to have been made.

In the very interesting report on foaming and priming by Foulk, recently published,* attention is drawn to the possibility of priming taking place with pure water, but, except under special conditions, we have not been able to confirm this. In the literature, however, no attempt appears to have been made to find a quantitative method for studying the extent to which priming takes place, and statements are limited as to whether it occurs or not.

Methods of Investigation

Many of the investigations on the subject deal with the experiments carried out in glass vessels at atmospheric pressure, and we may say at once that, after having made a considerable number of these, we discarded them as being quite useless as a guide to what may happen inside a boiler under 100 lb. pressure or more. Even those workers who have used an experimental boiler have often confined themselves to pressures as low as 10 lb., and have drawn conclusions from them which we cannot confirm. Thus 20 years ago McGill† found that foaming took place at 10 lb. pressure when the concentration of sodium salts reached 1,500 parts of Na_2O per 1,000,000, and he presumes that the effect would have been much increased in a boiler working at 200 lb. pressure. As will be shown below, however, the reverse is the case, priming being reduced and not increased with rising pressure. Some interesting experiments were reported by Mattson and Millard in 1925‡ in investigations on the connection between surface tension and priming. These were made in an experimental boiler at 75 lb. pressure, but unfortunately the arrangements are not described in detail, and it is not easy to compare their results with ours.

Our experiments have been carried out in three stages, the first being small-scale laboratory trials in an experimental boiler working at 100-150 lb. pressure, the second in a stationary boiler of locomotive type having a capacity of 600 gals., and the third in locomotives in ordinary service.

Appearance in the Boiler

With the aid of the sight glasses, observations were made as to the nature and movement of the water surface and the formation and breaking of bubbles. The sight glasses afforded a view through the water itself, and of the way in which bubble formation takes place below the surface. It appeared that with the steam valve shut, steam bubbles were formed at the heating surface, and, passing upward through the liquid, broke on the water surface. With all waters (including distilled water) whenever the steam valve was opened, the water space became filled with innumerable bubbles, some of which did not rise rapidly to the surface, but remained almost suspended in the water. Further, when the valve was open, the bubbles rising to the steam space did not break immediately, but formed a layer upon the water surface. As the valve was opened wider (i.e., as the rate of evaporation was increased) the thickness of this layer grew, and it rose higher and higher into the steam space until finally it reached the level of the valve, and "priming" ensued.

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*Journal of the Society of Chemical Industry—July.

*J. Amer. Water Works Assoc., 1927, 17, 160.

†J. S. C. I., 1904, 23, 351.

‡Ind. Eng. Chem., 1925, 17, 685.

It is supposed that this is identical with what is happening inside a locomotive boiler, i.e., that when the regulator valve is open there is always present on the surface of the water a layer of steam bubbles, and that "priming" ensues when this layer has risen so that it entirely fills the steam space and pours through the valve.

With distilled water in the boiler, up to 180 lb. pressure, no appearance suggestive of priming could be observed. A thin layer of bubbles formed on the water surface, but they broke so rapidly that, however much the steam valve was opened, they did not rise any appreciable distance into the steam space. The thin cloud emitted on blowing off appeared to consist only of dry steam, and there was an entire absence of the characteristic opaque cloud close to the valve which is seen when water-drops are present. When a natural or artificial saline water is evaporated, the concentration, of course, steadily rises as evaporation proceeds, and when the steam valve is closed the appearance of the water surface in no way differs from that of distilled water, even when the concentration of sodium salts is as high as 8,000 ppm. But as evaporation proceeds and concentration increases, the bubbles gradually increase in size, number, and stability, and rise more and more into the steam until they ultimately fill it. The cloud emitted is heavily opaque with drops of water, and has been actually found to contain up to 35 per cent of boiler water in the experimental boiler and up to 90 per cent (i.e., practically all water) with the large stationary boiler.

As has just been stated, no appearance of priming is seen while the valve is shut, and with any given solution it has to be opened to a definite extent before priming can be observed; that is to say, priming depends on the rate of evaporation. Further, if the pressure is increased, priming is greatly reduced. The extent to which it takes place, therefore, depends on the following variables, each of which is dealt with below in turn:

(a) The nature and amount of the substance dissolved or suspended in the water.

(b) The rate of evaporation.*

(c) The pressure.

(d) The water level.

Effect of Dissolved Salts

These experiments were carried out at a fixed pressure of 150-155 lb., with the water level 3½ in. below the steam valve, and a rate of evaporation (when the valve was opened for the test) of about 15 g. per sec. (equivalent to about 12 gals. per hr.) per sq. ft. of water surface. The concentration was gradually increased, and samples drawn from the valve from time to time and examined. The results are given in Table I.

The well water used contained 3,500 parts per 1,000,000 of dissolved solids and 120 deg. of total hardness (grains per gallon of calcium carbonate). The boiler was first filled with distilled water and the well water pumped in and evaporated to a concentration of 4,000 ppm. dissolved solids, samples of the steam ejected from the steam valve being taken at each increase in concentration of 500 ppm.

TABLE I

Concentration ppm.	Per cent of priming when the salt used was:				Priming of a well water
	NaCl	Na_2SO_4	Na_2CO_3	$CaCl_2$	
1000	0	0	0	0	0
1500	0	0	0	1	0
2000	0	6	4	4	3
2500	2	14	9	7	12
3000	9	18	14	10	16
3500	13	20	17	12	18
4000	18	22	19	14	20

There is a remarkable similarity in the behavior of the three sodium salts, and the prevalent idea that sodium carbonate is a specially objectionable constituent of a boiler water on account of priming receives no support. Of the three sodium salts, the sulphate is the worst.

With regard to practical experience with alkaline waters, we have received no reports as to excessive priming from the western section of the railway (Sennar to El Obeid), where our most alkaline waters are. Cases do occasionally occur, but these have always been found to be associated with unusually high concentrations of total dissolved solids.

No evidence of priming was obtained when the boiler was filled with a solution of calcium sulphate saturated at the room temperature, and therefore containing considerably more than could be dissolved at the boiler temperature according to Hall, Robb, and Coleman.*

Effect of Suspended Solids

Priming is very commonly attributed to the presence of suspended matter in the boiler; indeed, this is regarded by many writers as one of the really proved causes of the trouble (see Koyl). Our investigations have entirely failed to confirm this.

The problem of the relationship of suspended solids and priming appeared to be such an important one that running trials were carried out with locomotives in ordinary service. To enable a complete run to be made on one water only between washings-out, an extra tank was attached to the tender. Trials with an unsoftened well water (dissolved solids = 800 ppm.; total hardness = 30 deg.), and with the same water softened to 3 deg. showed that priming commenced in each case at practically the same concentration of dissolved solids, i.e., about 3,200 ppm. In these trials, since the superheater elements in the boiler prevented the passage of most of the water through the cylinders to the chimney, the appearance of bubbling in the gauge glass and of water in the vacuum ejector were taken as criteria of priming. The concentration of the boiler water was easily determined by examining samples drawn from the bottom of the gauge glass.

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*Throughout this paper the term "rate of evaporation" is used to denote the rate at which steam and water are ejected from the steam valve. "Rate of ejection" would perhaps be a more accurate term.

*J. Amer. Chem. Soc., 1926, 48, 927.

The Effect on Priming of the Rate of Evaporation

Attention has already been called to the fact that nothing abnormal in the appearance of the water surface can be observed unless steam is being drawn off, and the connection between priming and the rate of working of an engine is well known in practice; an engine pulling well on the level often begins to prime when climbing owing to the greatly increased rate of evaporation called for.

The most satisfactory method of specifying the rate of evaporation seems to be in gallons per hour per square feet of water surface. The following table shows the effect of the rate of evaporation on the amount of priming, the rate being governed, of course, by the extent to which the steam-valve cock was opened.

TABLE II

Concentration of salts 3,500 p.p.m., pressure 125 lb.

Rate of evaporation	Percentage of priming Sodium chloride	Sodium sulphate	Sodium carbonate
9	7	7	9
11	16	22	16
13	25	33	24

The results show clearly the great effect of the rate of evaporation: the differences in behavior of the three salts may require further investigation, but the general conclusion is the same for all.

Influence of Pressure on Priming

The only reference on this subject we have found is that of McGill (loc. cit.), indicating that priming would increase with increasing pressure. The figures in Table III show that this is not the case.

TABLE III

Concentration of salts maintained at 3,500 p.p.m. Rate of evaporation 11 gals. per hr. per sq. ft. of water surface.

Pressure, lb. per sq. in.	Percentage of priming Sodium chloride	Sodium sulphate	Sodium carbonate
70	45†	about 75†	about 80†
100	26	32	40
125	17	21	25
155	13	18	17

†Results extrapolated from the priming curves. These figures are certainly not too low.

Influence of Water Level

Even in the case of distilled water there is a slight rise of the water surface and the formation of a thin layer of bubbles on opening the blow-off valve, and it is clear that if the exit pipe were near enough to the water surface some water would escape with the steam, that is, priming would take place. The closeness of the water surface to the exit pipe has similarly an important effect on the amount of priming in the case of saline solutions.

Table IV shows the enormous effect of lowering the water level in the case of priming in the large stationary boiler. The concentration of the water was 3,500 ppm., the pressure 105 lb., and the rate of evaporation 15 gals. per sq. ft. of water surface per hr.

TABLE IV

Water level	Per cent priming
Normal	95
1 in. lowered	60
2 in. lowered	nil

The influence of the drop in water level is very great, and it is unfortunate that, when an engine is beginning to prime, bubbling in the gauge glass and the consequent fear of the driver of misjudging the water level leads him to run it higher than normally, and this very much increases priming.

Organic Impurities in the Water

The organic substances which are commonly stated to cause or increase priming are mineral oils and grease and soap. We have not yet obtained direct proof or disproof of these statements, but we experienced considerable increase in priming on an occasion when lubricating grease from the pump was apparently carried over to the boiler. On the other hand, it is very unlikely that vegetable oils can cause priming: castor oil cures it, and linseed is often used as a scale-preventive. Experiments on this subject are in progress.

The Prevention of Priming

The only compound which appears generally known as a certain preventive of priming is castor oil, and while the mechanism of its effect is not understood, the fact is well established. We have made experiments in the laboratory and in the stationary boiler with the following results, the castor oil being added in the form of a 1 in 6 emulsion in 1 per cent soap solution, the emulsion being usually well diluted with distilled water before being pumped into the boiler.

General Conclusions

The experiments described do not support the view so often expressed that a sharp distinction can be drawn between a water which primes and one which does not. On the contrary, it appears that the question of whether a water will prime or not depends quite as much on the conditions under which evaporation is taking place as upon the nature of the water itself. As has already been pointed out, there is always present in the boiler on the water surface a layer of steam bubbles which will cause priming if its thickness increases sufficiently to fill the steam space; the thickness of this layer is governed by all the factors with which we have dealt. No attempt has been made in this paper to deal with the question in its theoretical aspect. The excellent discussion by Foulk (loc. cit.), indeed, indicates that it would be premature owing to the lack of sufficient data. It is for this reason that it appears to us undesirable to attempt to separate foaming, violent ebullition, etc., as independent phenomena. As far as our observations go, rise of water level, bubbling in the gauge glass, and ejection of wet steam are parallel phenomena, and a cure for one will be a cure for all.

The feeling cannot be avoided that many of the statements as to causes of priming (especially those referring to the presence of suspended matter) are based rather on a priori grounds than on actual observations. It is exceedingly rare to find recorded the composition of the water from the boiler when priming occurred, so that there is no evidence that what took place in the presence of suspended solids was not due to a concomitant increase of concentration of dissolved solids.

Alkalinity as a cause of priming appears to be disproved by our experiments. This is an extremely important matter in practice, as it is commonly held that the small amount of free alkali (up to about 100 ppm.) left in a water which has been softened to 0 deg. hardness, may be a cause of priming, and its is, therefore, customary to stop the softening some way from zero. In one case we were even informed that softening below 10 deg. was inadvisable. We ourselves cannot account for this. Trials with bad water on actual runs showed no difference in priming whether hard, soft, or mixed water was used. The concentration of dissolved solids in the boiler appeared to be the only factor of importance. There may, of course, be other objections to the use of water of zero hardness which are unconnected with priming: thus, when condensed water is used, it is customary to add a little lime to correct for the invariable acidity of the water, and it is possible that (owing to the formation of a thin protective scale) a slightly hard water is less corrosive than a slightly alkaline soft one, but we are not aware of the existence of satisfactory evidence on which this question can be decided. From the statements of Paul,* however, the corrosive effect of softened water is due to incomplete softening, and where complete softening has been carried out no corrosive effects are observed.

Summary

(a) Priming in a boiler is caused by the layer of bubbles on the water surface increasing in thickness and stability to such an extent that it reaches the steam exit pipe so that water is ejected with the steam. It is accompanied by a rise in water level which increases the effect.

(b) This may be brought about by a high rate of evaporation, a low pressure, or a high water level.

(c) In the case of any of the above, the effect is greatly increased by a high concentration of dissolved solids.

(d) Sodium carbonate has no greater effect in producing priming than other salts.

(e) The effect on priming of finely-divided calcium carbonate or boiler scale is negligible.

(f) There appears to be no important difference as regards priming between hard and soft water.

(g) Castor oil exerts a very powerful effect in suppressing priming, and enables a water of high concentration of dissolved solids to be used in a boiler.

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*"Boiler Chemistry and Feed Water Supplies," 1923, 176.

Iron Blast-Furnace Reactions

Examination of samples of gases from various planes in the iron blast furnace show that certain parts of the furnace do more work than others because the stock moves unevenly, says the United States Bureau of Mines, Department of Commerce, whose investigators have taken thousands of gas samples from different planes of numerous blast furnaces. Ideal operation would seem to require uniform flow of stock and gas. As it has been shown that the combustion zones control the movement of stock in the furnace, Bureau of Mines' investigators have suggested that more uniform movement might be obtained by rearrangement of these zones in an elliptical or oval hearth, not wider than twice the length of the zone of combustion. By so doing the average temperature of the hearth would be higher than in present furnaces and combustion would be proceeding uniformly throughout the hearth area; therefore, stock movement would be uniform in the stack.

Exact knowledge of the chemical and metallurgical reactions in the interior of the blast furnace is becoming increasingly important to furnace operators, point out S. P. Kinney, P. H. Royster, and T. L. Joseph in Technical Paper 391, recently issued by the Bureau of Mines. With a view to providing basic data and thus aiding the iron and steel industry, the Bureau of Mines has attempted to determine the reactions as they take place in the interior of the furnace In this work the Bureau used two methods of attack: A study of the composition of the gases across a series of planes between the tuyere level and the stock line, and a study of the composition of stock samples removed from various planes. The investigation reported in Technical Paper 391 is analogous to a number of others that the Bureau has conducted, as its Minneapolis, Pittsburgh, and Birmingham-Tuscaloosa experiment stations, on the reduction of iron oxides and the combustibility of coke.

Results of a study of the reduction of iron oxides in a 300-ton furnace, where the gases were sampled across a series of planes lying between the tuyere level and the stock line, are given in Bureau of Mines Technical Paper 391, "Iron Blast-Furnace Reactions," which may be purchased from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a price of 15 cents.

Waste Heat Boiler Application

(Continued from page 449)

work is shown at A with 9 in. fire brick, 4 in. insulating brick and 4 in. common brick outside the insulating brick to hold it in place and protect it. A bitumastic coating is applied to the outside of the common brick to seal against leaks. This wall has been used in several cases and is very satisfactory. The advent of good insulating brick makes it possible to design new types of settings that bring the radiation loss to below 1 per cent and probably new settings can be designed that will reduce the weight of settings to a point that steel supports can be lightened and money saved on the total job.

Auxiliary Firing

Waste heat boilers are generally operated at or below builders rating. The effectiveness of this heating surface can be increased by auxiliary firing. Where the furnace supplying the waste gases has a balanced draft at the boiler entrance, there is no difficulty in doing this. If there is a suction at the entrance to the boiler, it is harder to do but can and has been done successfully. Here it requires a knowledge of the conditions surrounding each proposition and a special study of same.

Sheets for the Automobile Industry

A Survey of the Change in the Grades of Sheets Brought About by a Study of Requirements. Co-operation Between Manufacturers and Purchasers. Breakage Tolerance a Factor

By R. C. TODD*

THE manufacture of the automobile has undergone a growth in the past 20 years that is unprecedented in the history of industry, and the art of making highly finished steel sheets has progressed in harmony with this development.

This remarkable growth brought about through necessity the evolution of sheet metal for automobile bodies, from a few grades of steel to a wide range of grades which meet the most exacting requirements of drawing operations and surface finish.

Prior to 1910 the automobile industry ordered full pickled, three-pass cold rolled and annealed, stretcher leveled sheets for auto body requirements. These sheets were flat formed around wooden body frames. For fenders a full pickled, three-pass cold rolled and annealed grade was ordered to answer for beading and seaming.

In those days an attractive auto body job could be turned out only by the application of 15 to 20 coats of paint with much rubbing, glazing, and puttying, and with long processes of air drying to finish them. The fenders were flat topped and required about four coats of dipped enameling with much rubbing between operations.

From that time to the present, quantity production has been possible with resultant economies through the ability of the steel mills to produce more highly finished sheets that would remain comparatively free from surface disturbance through the stamping operations.

Each year from 1910 to 1926 has brought improvements in the art of steel making that have permitted fabricating and finishing economies in body and fender building.

Ordering by Purpose

Contributing to this cooperative success has been the fact that the automobile interests discontinued the specifying of sheets by treatment processes, and instead specified their sheet requirements by part purposes.

In this way the terminology of steel sheet grades for the exposed parts of automobiles has been developed, such as:

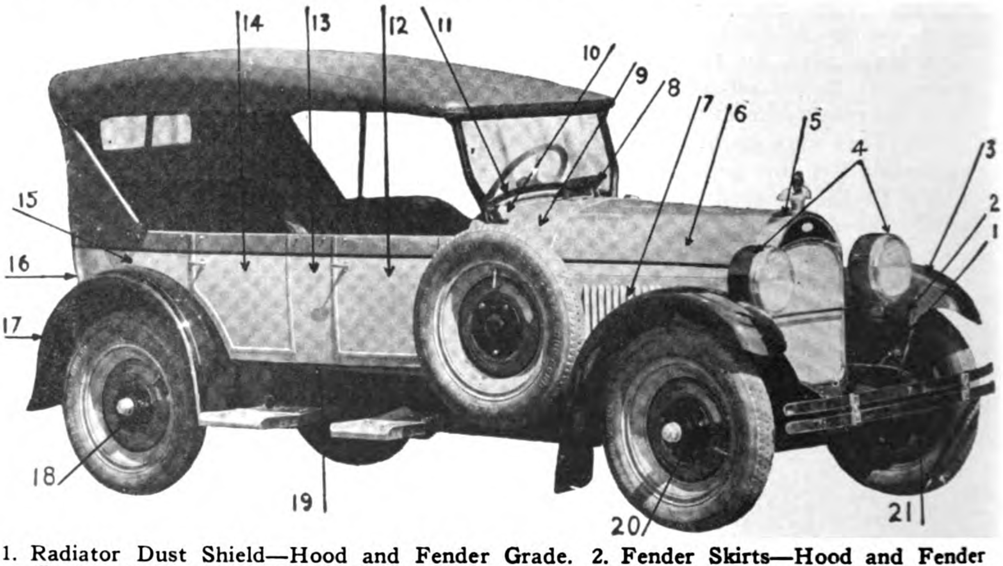
Auto body,
Auto body deep drawing,
Auto body extra deep drawing,
Hood and fender,
Hood and fender deep drawing,
Hood and fender extra deep drawing,
Radiator casing steel,
Lamp stock,
Door stock,
Crown fender steel.

These various terms are supplemented with information as to the car and particular part of the car on which the item is to serve.

To aid the automobile manufacturer even more, the steel mills send their service engineers to study the parts to be manufactured, the proposed method of stamping and drawing and the ultimate surface finish required in order that they can recommend the most suitable and efficient annealing and cold rolling treatment to the sheets.

Auto body grade infers that the material is to have a surface standard adaptable to a paint finish and the hood and fender grades infer that the finish must answer for dipped enameling.

The automobile steel sheet buyer, by taking the sheet producer into his confidence and by showing him the part which the material must serve and the process by which it is made, places upon the sheet producer the responsibility for supplying a quality of sheet suitable for the purpose. The hazard for the material's answering the requirements could not be assumed by the sheet producer, nor would he have had the opportunity to develop improved quality if



1. Radiator Dust Shield—Hood and Fender Grade. 2. Fender Skirts—Hood and Fender Grade. 3. Front Fenders—Hood and Fender Grade Deep Drawing. 4. Headlight—Special Lamp Body Steel. 5. Radiator—Radiator Casing Steel. 6. Hood Top—Hood and Fender Grade. 7. Hood Side—Hood and Fender Grade Deep Drawing. 8. Cowl Ventilator—Auto Body Grade. 9. Cowl—Auto Body Grade. 10. Cowl Lamps—Special Lamp Steel. 11. Instrument Board—Hood and Fender Grade. 12. Doors—Auto Body Grade. 13. Center Panel—Auto Body Grade. 15. Rear Side Panel—Auto Body Grade Extra Deep Drawing. 16. Back Panel—Auto Body Grade Deep Drawing. 17. Rear Fenders—Hood and Fender Grade Deep Drawing. 18. Disc Wheels—Disc Wheel Steel. 19. Running Board Apron—Hood and Fender Grade. 21.—Brake Drums—Special Brake Drum Steel. Gasoline Tank—Alloy Coated Steel for Gas Tanks. Oil Pan—Special Oil Pan Steel.

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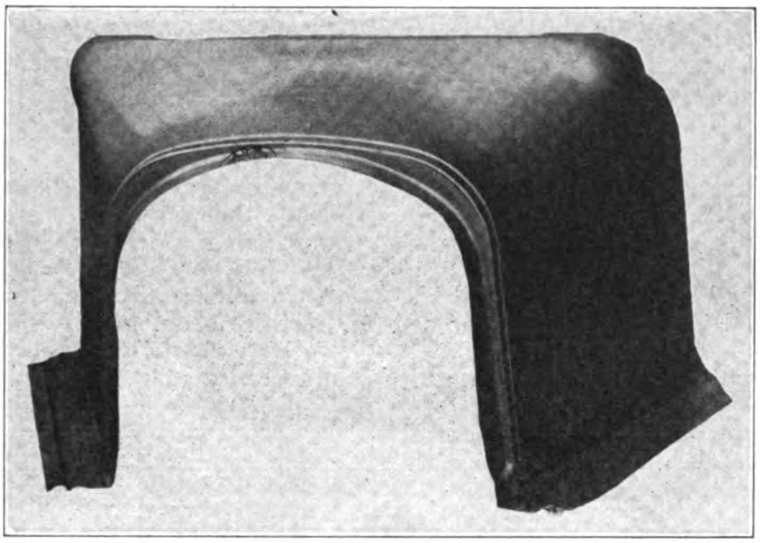
*The American Rolling Mill Company, Middletown, O.

the buyer had restricted the information of parts and processes or had ordered by physical tests or sheet treatment processes.

The great distance of foreign automobile manufacturers from the American sheet producers has necessitated a further standardization of grades. For instance, our auto body extra deep drawing grade as sold for export work is of a quality which we have found to be superior for more varied severe requirements of cowl, quarter panel and tonneau parts than any other character of sheet we produce. We, however, make about eight differently processed sheets which are sold under the term of auto body extra deep drawing for American requirements, but for export work we supply only one definite grade which in our opinion is the best one. By this practice the purchaser can ascertain the definite quality that best suits his varying requirements and purchase standardized grades that will uniformly meet his needs.



Drawn cowl—auto body extra deep drawing grade.

The overseas purchaser, in such practice, necessarily concentrates his purchasing from one source of supply to gain the uniformity in quality for each grade purchased.

Steel companies produce automobile steel sheets through different and varying equipment. An auto body deep drawing grade from one mill would not be made in the same manner as would auto body deep drawing grade by another producer. While the product of auto body deep drawing grade from one company might be somewhat similar to the product by that name from another company, there, however, would be a distinct difference.

These differences of processing definite grades occur through every department of steel making, bar rolling, pickling, hot rolling, cold rolling, and annealing, as there is no uniform equipment or treatment that is generally used by all mills.

The automobile sheet buyer when ordering material also characterizes his requirements as deep drawing or extra deep drawing, according to the breakage hazard, extra treatment, and the assurance which he desires for satisfactory finished results.

Breakage Tolerance

Until a stamping requirement has been successfully standardized a fabricator makes no claim for breakage.

A claim for breakage is based only on the total stampings produced in large quantities from one continuous set-up of the dies. On the original set-up of stamping dies, generally there are from 20 to 50 blanks scrapped during the adjustment process, which breakage is not figured in the quantity run.

When a stamping requirement is uniformly produced with a breakage of a certain percentage, then this percentage is the basis for the breakage tolerance on future runs. In no case is breakage tolerance less than 3 per cent.

There are so many variables to cause breakage in the way of lubrication, hold-down tension, press stroke, scored dies, improperly placed blanks, etc., irrespective of the quality of the steel, that the varying percentages for breakage tolerance are considered necessary. Any sheets that break because of being laminated are, however, subject to prompt credit to the fabricator without any tolerance whether it be one blank or a thousand.

The results from the last 15 years of progress in the manufacture of automobile steel sheets has reached a stage that was undreamed of 15 years ago. As the necessities develop for further fabricating and finishing economies, it is to be hoped that the steel mills will be able to match the needs of the future and contribute their share toward the further progress of this marvelous industry.

John Moody Says Manufactured Gas Industry Is Sound

The manufactured gas industry has established an excellent record from the investor's point of view, according to John Moody, well-known financial statistician. Although somewhat overshadowed by the electric power business in the eyes of the public, he says the expansion of the gas industry has been rapid and uninterrupted for more than two decades, a remarkable accomplishment in view of the readjustment from an illuminating to a heating service which has taken place during the time consequent upon the development of electricity.

"The sales of manufactured gas as reported by the American Gas Association amounted, in 1926, to 459,326 million cu. ft. as compared with 421,400 in 1925, 405,200 in 1924, 384,722 in 1923 and 178,229 in 1912," says Mr. Moody. "A feature of this expansion was the constant growth of the consumption of gas for industrial purposes and the successful efforts of gas companies in finding new and diversified uses for their product. Aggregate net operating earnings of eight leading gas companies amounted in 1926 to $33,029,000 as compared with $25,109,000 in 1925, $24,822,000 in 1924, $25,880,000 in 1923 and $25,213,000 in 1922."

Thus, the gain in 1926 was 31.54 per cent, due chiefly to a notable increase in earnings of the Consolidated Gas Company of New York and the Brooklyn Union Gas Company. At the same time, the ratio of operating net to gross showed a substantial improvement, rising from 21.43 per cent in 1925 to 24.86 per cent in 1926, a record figure for recent years.

WITH THE EQUIPMENT MANUFACTURERS

A Unique Car Dumper Installation

At the new plant of the Florida Portland Cement Company, Tampa, Florida, there has been installed for the handling of cement rock from railroad cars to the storage yard at the crusher plant, a Wellman Car Dumper having a number of very unique features, as can readily be seen from the accompanying photographs.

Fig. 1 shows the dumper in normal position to receive a car and to the right of the dumper the inclined runways upon which the dumper is rolled into the dumping position.

Fig. 2 shows the dumper with car part way up the incline, and Fig. 3 shows the dumper in dumping position at the top of the incline.

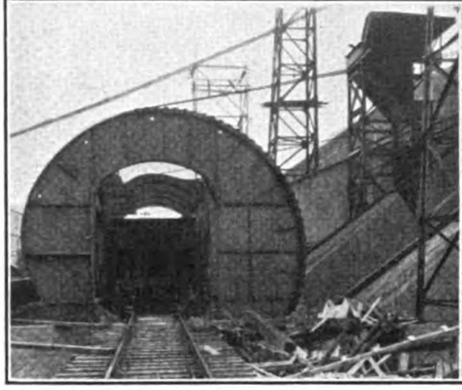


Fig. 1

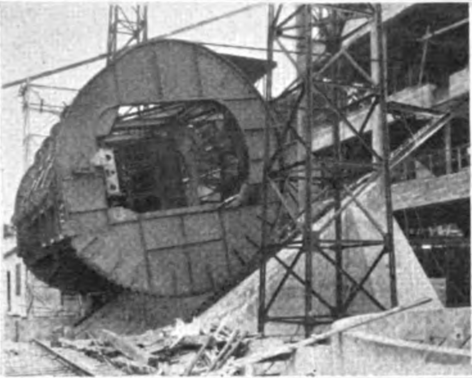


Fig. 2

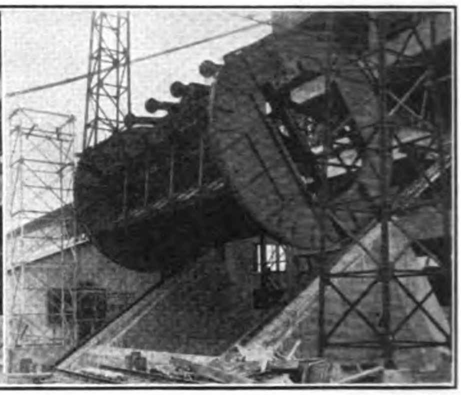


Fig. 3

The peculiar conditions surrounding this installation required an equipment which would unload the cars without providing the usual storage bins under the dumper. The general level of the ground is only a few feet above water level, and it was desired to provide storage for a day's use at the crusher plant without rehandling, and by rolling the dumper up an incline the bin was not necessary, and sufficient storage was provided to meet the requirements.

As will be observed, this dumper, while similar in many respects to the well-known Wellman Revolving Car Dumper, instead of being "revolved" upon equalizing rollers carried in structural steel bases secured to the foundation, is "rolled" into its dumping position upon steel girder runways which are inclined at approximately 35 deg., and the machinery for "rolling" the dumper up the incline is mounted on foundations at the ground level under the crusher tower, and consists of two drums spaced 50 ft. center to center, each drum being driven by a double reduction of cut gearing, the second intermediate shaft extending the full distance between the drums, being geared at the center to the driving motor, and being provided with a manually operated brake used only in an emergency, the service brake being electrically operated and attached directly to the motor.

The platen is supported on forged steel flat tread rollers, which run on flat plate paths riveted to the cross frame of the tipple.

The car clamps are of the pivoted counterweight type, there being four clamps provided for holding the cars in position while dumping and return cycle of the dumper. Each clamp has its own independent operating mechanism, and as all the clamp mechanism is carried at the rear side of the dumper there is unobstructed dumping except for the narrow clamp beams themselves.

When the dumper is in position for the start of the dumping cycle, the counterweight rollers rest upon the inclined guides and the chain is nearly unwound from the chain wheel and the clamp counterweight ropes are nearly unwound from the holding rope drum and the lifting rope is wound upon the clamp lifting drum. As the dumper begins to rotate in the dumping direction, the counterweight rollers will move up the inclined guides, which will slacken the chain and allow the clamp lifting ropes to pay off the lifting drum and the slides and beams will lower, due to their weight, until they rest upon the top of the car. During this part of the operation the clamp counterweight, or holding ropes, are wound in the same amount as the lifting ropes are unwound. When the slides and beams rest upon the top of the car, rotation of the drum ceases. After the counterweight has left the inclined guides, the counterweight arm hangs vertical until the pawl is thrown into engagement, which occurs after the cradle has rotated about 45 deg. During the rest of the dumping cycle the counterweights act as a fixed arm in reference to the drum center, but the actual, or gravity arm, constantly increases until the car is dumped.

This arrangement produces the greatest holding force upon the car at that part of the cycle when the car and its contents have the greatest tendency to leave the platen.

The pawl is brought into engagement with the ratchet wheel on the holding drum by means of a roller. The pawl has an extension with the roller at its end, and when the dumper has revolved about 45 degrees, this roller strikes a cam pivotally fastened to the dumper frame and forces the pawl to engage the ratchet on the holding drum and compress the pawl holding-out spring.

After the contents of the car have been discharged, reverse rotation of the dumper will reverse all operations, and the slide and beam will be raised to their original position by the pull of the chain caused by the counterweights rolling down the inclined guides. This will revolve the chain wheel in the proper direction to wind up the lifting ropes.

This dumper is driven by one 115-hp. motor provided with a full torque magnetic brake, and a controller of the magnetic switch type. The machine is fitted with a geared limit switch to slow down and stop the rolling of the dumper in either direction.

It will be of interest to note that this dumper will handle open top railway cars from 7 ft. to 12 ft. 6 in. high; 9 ft. to 10 ft. 6 in. wide and overall lengths of 50 ft. inside of cars, and having a loaded weight of car and contents of 220,000 lbs. i.e., cars with 80 tons capacity of rock, plus approximately 10 per cent overload and a tare weight of 45,000 lbs., at the rate of 20 cars per hour.

The Cowham Engineering Company of Chicago, Ill., were the consutling engineers in the building of this plant, the dumper itself being designed and constructed by The Wellman-Seaver-Morgan Company of Cleveland, Ohio, specialists in the material handling field.

Earlyite Alloy Cast Iron

A new alloy metal has been developed and is being placed on the market by the firm of W. J. Early Sons Foundry Corporation, 812 Sarah Street, S. S., Pittsburgh, Pa.

In introducing the possibilities and merits of Earlyite cast iron, a patented alloy metal containing such elements as chromium, nickel, molybdenum and manganese, capable of withstanding high temperatures and hard wear, and possessing extraordinary tensile strength, the claim is not made that the product is a cure for all ills which develop in the use of ferrous metals. It is maintained, however, that within the range of the many different mixing formulas, there exists a metal composition that will solve a great number of the troublesome problems in mill and factory caused by abnormal heat and wearing conditions.

As a heat resisting metal Earlyite will withstand a temperature of 2,000 deg. F. In combating hard wearing conditions it will outlast ordinary cast iron by a ratio of about 4 to 1. A unique feature of this alloy is that castings can be made with a hard chilled surface of any desired depth and location. The degree of hardness is controllable and castings of either a machinable or non-machinable composition may be produced.

For steel plants, Earlyite is used for Rolls of all kinds, mill and button guides, hammer dies, furnace doors and frames, furnace rails or skids, annealing boxes, ingot molds, grate bars, wearing plates and other castings which must resist high temperature or severe wearing service.

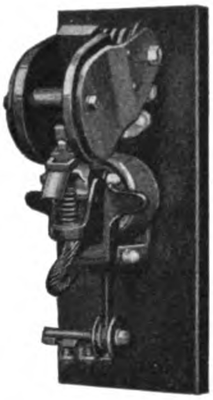
In the manufacture of brick and other clay products, where hard wearing surfaces are essential, Earlyite will prove of great value, not only in rendering long service, but in eliminating the frequent replacements of ordinary metal castings. For grinding tires and plates, scraper blades, screen plates, worm propellers, pug mill knives, bottom wearing plates, and all other parts in contact with abrasive materials, Earlyite is strongly recommended.

Extensive tests, carried on in a practical manner for many months, and the results obtained from alloy castings now in actual service under unusual and severe conditions, have been highly satisfactory.

The inventor of Earlyite is Mr. John N. Early, president of the W. J. Early Sons Foundry Corporation, Pittsburgh, Pa. Patent rights are protected in both United States and Canada.

New Designed Contactors Show Remarkable Life Tests

Improved designed magnetic blowouts on their d.c. mill contactors which will result in a material reduction in maintenance expense are announced by The Cutler-Hammer Manufacturing Company. These improvements are the result of research and a series of tests undertaken coincident with the development of the inductive time limit type of controller for steel mill applications.



In making the research, actual life tests were conducted to determine the effect of the shape and the material used in the contacts themselves, the shape and material of the arcing tips, the location and intensity of the magnetic blowouts, and the material used for the magnetic blowout shields.

The design finally adopted incorporates those changes which showed up best under these actual tests. All tests were made under 100 per cent overload conditions, or, in other words, at 200 per cent full load contactor rating. The results obtained, therefore, are comparative rather than serving to establish, a contactor rating.

A 300-amp. type No. 142 butt-contact-type mill contactor, operating at 200 per cent load, alternately making and breaking a 600 -amp, 250-volt circuit, gave an average life of 263,000 operations for each set of contacts. One remarkable result noted during these tests was the fact that instead of decreasing one-third in life after each renewal, as is usually the case, the new contacts actually increased in life.

The tests ran 2,000,000 operations, requiring eight renewals of contacts. Whereas the first set of contacts gave only 222,239 operations, the sixth set had a life of 261,130 operations, the seventh set 275,859 and the eighth set 265,023 operations. At the end of the 2,000,000 run the blowout shields were still in excellent condition and good for at least 2,000,000 additional operations. The illustration shows a close-up of the entire new switch mechanism.

These improvement in contactor life are sure to effect considerable saving in renewal parts annually. In addition, the cost of maintenance and inspection will be materially reduced because the contacts and blowout shields will not need to be renewed as frequently as before.

TRADE NOTES

The International Clay Machinery Company of Dayton, Ohio, has recently closed a large contract for complete annealing equipment with the American Sheet & Tin Plate Company for the new Gary continuous annealing ovens. This company also manufactures Boesch trucks for tin plate and tin mill works, charging cars, ingot cars, dump cars and other types of cars such as used in iron and steel plants. Among the companies with whom contracts have been completed are: Bethlehem Steel Company, Saginaw Malleable Iron Works, Standard Sanitary Manufacturing Company, Jones & Laughlin Steel Company, Eastern Malleable Iron Company, Follansbee Steel Company, Youngstown Sheet & Tube Company, Bell City Malleable Iron Company, National Malleable Castings Company, Kohler Company, and others.

* * *

The International Combustion Engineering Corporation, 200 Madison Avenue, New York City, has formed a subsidiary, the Dry Quenching Equipment Corporation. This subsidiary will erect plants for the dry quenching of coke according to a process developed by Sulzer Brothers, Winterthur, Switzerland. Walter Sennhauser, at present connected with Sulzer Brothers at Winterthur, will act as chief engineer for the new company. George E. Learnard, president of International Combustion Engineering Corporation is chairman of the new company whose directorate consists of H. D. Savage, G. G. G. Hunter, George H. Hansel, Hans Sulzer, F. Oederlin, and E. N. Goodwin.

* * *

The Blaw-Knox Company, with general offices at Pittsburgh, Pa. and with plants at Blawnox, Pa. and Baltimore, Md. has purchased the Milliken Brothers Manufacturing Company of New York. The consolidation of the two companies became effective on September 1.

The Blaw-Knox Company is well known because of its line of steel specialties including steel forms for concrete construction, steel buildings, open hearth furnace equipment, air preheaters, hammer welded products, steel transmission towers, automatic concrete measuring devices, steel bins, clamshell buckets, etc.

The Milliken Brothers Manufacturing Company was originally organized as Milliken Brothers, Inc. in 1857. The products of the Millikin Brothers Manufacturing Company are transmission towers, radio towers, and standard steel buildings. A considerable amount of business of the Milliken Brothers Manufacturing Company has been in the export field and the present Milliken organization will continue to function in this field and in addition will take over the management of the export business of the Blaw-Knox Company on all of its products.

The Blaw-Knox Company will continue with its present organization to handle domestic business and the acquisition of the Milliken Company will make no change in this line. Manufacturing for both companies will be concentrated at the Blaw-Knox Company plants at Pittsburgh and Baltimore.

The Falk Corporation of Milwaukee, Wis., manufacturers of herringbone gears, speed reducers, flexible couplings, oil engines and steel castings, announces the opening of an office in Portland, Ore., at 720 Terminal Sales Building, Twelfth and Morrison Streets. This office will be in charge of Mr. John Jurgensen, who has been in the company's New York office for seven years.

* * *

The Andrews-Bradshaw Company of Pittsburgh, Pa., who have for some time past owned a controlling interest in the Tracy Engineering Company of San Francisco, have recently acquired full ownership of that company's entire plant. While many of the original basic patents were held jointly by the two companies, the purchase of the Tracy Engineering Company gives the Andrews-Bradshaw Company absolute title to all the valuable Tracyfier patents.

Since the purchase of the Tracy Engineering Company by the Andrews-Bradshaw Company, the factory has been moved to Pittsburgh. While retaining the basic principles as before, the greatly improved manufacturing facilities have made it possible to embody a number of new features, with the result that the Tracyfiers being made in Pittsburgh have many advantages over those formerly made on the West Coast. Deliveries can be made more promptly because of better shipping facilities; less time will be lost enroute.

The organization has been augmented by the transfer of Mr. George Ahlworth, former plant superintendent of the Tracy Engineering Company, and Mr. Carl Peterson, chief draftsman, who is also moving East to join the Andrews-Bradshaw Company forces.

Rudolph Diesel Award for 1927

Announcement is made that Mr. W. F. Joachim, mechanical engineer, Langley Memorial Aeronautical Laboratory has been selected to receive the Rudolph Diesel Award for 1927, consisting of a suitable certificate and a cash prize of $100, for his paper entitled "Oil Spray Investigations of the National Advisory Committee for Aeronautics," which was presented at the Oil Power Week meeting, April 21-23, 1927, at Pennsylvania State College, State College, Pa.

The committee of award consisted of F. Thilenius, division superintendent, Prairie Pipe Line Company; F. G. Hechler, professor of engineering research, Pennsylvania State College and R. Miller, assistant chief engineer, oil engine department, Ingersoll-Rand Company.

The Rudolph Diesel Award, established in honor of the man whose name is so closely connected with the modern oil-engine, is given annually in connection with the activities of Oil Power Week, for the best written contribution towards the advancement of oil engines delivered at any of the meetings held throughout the country. In this year's celebration of Oil Power Week, 106 meetings of national technical societies were held in 31 states; 88 different papers were presented, all of which had been especially prepared for the occasion.

The national committee in charge of Oil Power Week consisted of R. P. Anderson, D. L. Fagnan, J. D. Jones, D. F. Killeffer, L. H. Morrison, L. H. Roller, and E. J. Kates, chairman.

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NEWS OF THE PLANTS

The new 18-inch billet mill at the South works of the American Steel & Wire Company, Worcester, Mass., was given a preliminary trial during the week of August 18. The rod mill will be operated early in September. Both units will probably be on production this month. After the completion of the new units, the No. 2 rod mill will be remodeled.

* * *

The Edgewater Steel Company has purchased 28 acres adjoining its Edgewater company plant at Oakmont, Pa., near Pittsburgh. The tract is on the Allegheny river and adjacent Pennsylvania railroad. This acreage doubles the site of the Edgewater company. It was purchased from the Carnegie Steel Company.

* * *

William P. Barba, Philadelphia, and Alexander F. Crichton, Wilmington, Del., receivers for the Penn Seaboard Steel Corporation, have also been appointed receivers of the Tacony Steel Company, an affiliated organization with plant at Tacony, Philadelphia. The court has appointed appraisers to determine the value of the Tacony property prior to its being offered for sale.

* * *

Interests associated with the Laclede Steel Company, St. Louis, have purchased control of the Southern States Steel Company, with warehouses at Dallas, Tex., according to an announcement by S. R. Tyler, vice president and secretary of the former company. The Texas company will be reorganized as the Southern States Steel Corporation in charge of W. L. Thickstun, vice president. Richard S. Hill, for some years with the Concrete Steel Company, and recently in charge of the Laclede Steel Company's Kansas City office, has been made sales engineer. The Southern States Steel Company has for many years been engaged in the fabrication of steel bars for concrete reinforcement and in the manufacture of spirals, spacers, etc. Its fabrication plant and warehouses are located at 503 South Haskell Avenue, Dallas.

* * *

The properties of the Belfont Steel & Wire Company, Ironton, Ohio, have been placed in the hands of a committee representing the creditors of the company, who will manage the company for a period of one year. Claims of all creditors will be held in abeyance during that time.

The committee consists of J. C. Miller, representing the Fifth-Third Union Trust Company, Cincinnati; D. H. Putnam, Ironton By-Product Coke Company; O. D. Hayes, First National Bank of Ironton; W. G. Woollenweber, Wheeling Steel Corporation, and D. T. Croxton, Cleveland-Cliffs Iron Company.

The company owns the Belfont and Sarah blast furnaces and has a two-thirds interest in the Ashland Steel Company, Ashland, Ky. The Belfont stack, will be blown in again as soon as necessary repairs of the furnace lining can be made. The nail and wire mill already have resumed operations.

* * *

Directors of The Brown Hoisting Machinery Company, Cleveland, and Industrial Works, Bay City, Mich., have approved plans for a merger of the two companies, to be made effective when ratified by their respective stockholders at meetings which will be held in the near future. Discussions leading to this merger have been proceeding for many months, and this announcement is the culmination of intensive work on the part of the late Mr. E. B. Perry, formerly president of Industrial Works, Mr. Alexander C. Brown, president of The Brown Hoisting Machinery Company, and other executives of the two companies.

The Brown Hoisting Machinery Company was founded in 1880 by Alexander E. Brown. This company designs and manufacturers hoisting and conveying appliances and heavy handling machinery of all descriptions, including locomotive cranes, grab buckets, combination shovels and cranes, ore unloaders, bridge cranes, gantry and portal cranes, trolleys, hand traveling cranes, and conveyor equipment. The principal plant of the company occupies nine and one-half acres, fronting on St. Clair Avenue in the city of Cleveland, 10 minutes ride from the heart of the city, and is served by switch tracks of the New York Central and Pennsylvania Railroads. The company also owns at Elyria, Ohio, 20 miles from Cleveland, 25 acres of land on which is situated a modern and completely equipped iron and bronze foundry.

Industrial Works was founded in 1873 by George C. Kimball, James Clements, E. Wells, and Charles R. Wells. Mr. W. L. Clements of Bay City, was president from 1891 until his retirement in 1924, since which time Mr. E. B. Perry was president until his death on August 7 last. This company designs and builds locomotive cranes, wrecking cranes, heavy duty and full revolving pile drivers, crawler cranes and shovels for gasoline, steam, electric, or Diesel operation, gantries, pillar cranes, rail saws, buckets, and steam hammers. It also manufacturers large coke oven machinery, including coke pushers, coal chargers and clay carriers. The Industrial Work's plant covers 29 acres, consists of 60 buildings, has over 440,000 sq. ft. of covered floor space, and is served by five miles of its own railroad track, with motive power and rolling stock for internal transportation facilities. The plant is complete, having its own steel, iron and brass foundries, pattern shop, machine shop, structural shop, boiler and blacksmith shops, and all other departments necessary to build its product from the ground up.

The consolidation will join under one management over 2,100 people, and assets of approximately $13,000,000. The combined sales of both companies totalled over $7,700,000 in 1926. Both plants will be continued in operation, and no radical changes of any sort are contemplated.

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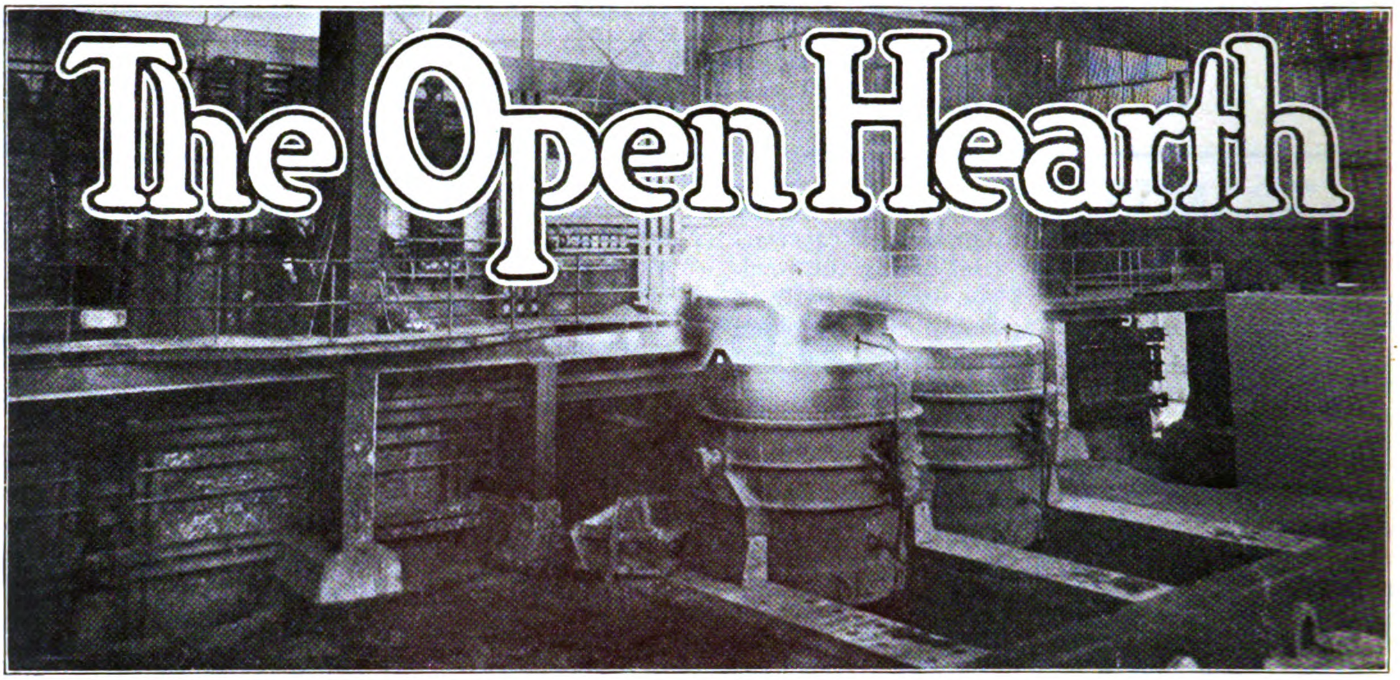
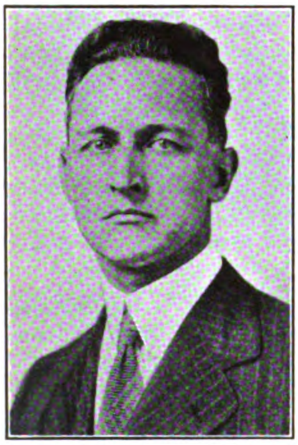
The Open Hearth



Mr. G. L. Fisk has been appointed chief engineer of the Mesta Machine Company, Pittsburgh, Pa. Mr. Fisk was formerly chief engineer of the Pittsburgh Crucible Steel Company, Midland, Pa., which position involved charge of engineering, construction and maintenance for the Midland plant, as well as of major engineering projects and installations made by the Crucible Steel Company of America.



After his education in Sweden he became associated with Cambria Steel Company and later served as resident engineer for Julian Kennedy, Sahlin & Company, Ltd., during the construction of the Tata Iron & Steel Company of India.

Mr. L. Iversen, vice president of the Mesta Machine Company and formerly chief engineer will act in the capacity of consulting engineer.

* * *

William E. Brown, manager of the central station department of the New York district of the General Electric Company, has been appointed New York district sales manager of the company, Theodore Beran, commercial vice president of the company has announced. Mr. Brown's headquarters will be at 120 Broadway, New York.

* * *

Marcus A. Curran, of New York, at present assistant to vice president of the Graybar Electric Company, has been elected vice president and general manager of the Bryant Electric Company, Bridgeport, Conn., according to an announcement made by Walter Cary, president of the Bryant Electric Company. Mr. Curran will assume his new duties on September 1.

Mr. Curran has been very active in electrical association work. He is chairman of the Individual Membership Council of the Society for Electrical Development, member of the National Electric League Council, and has served as president of the Omaha Electrical Industry Association and the Cincinnati Electric Club for two terms in both cases.

* * *

Mr. A. T. Kasley, formerly head of the Research Department at the South Philadelphia Works of the Westinghouse Electric & Mfg. Company has been appointed consulting engineer, engineering department at that plant.

* * *

Walter R. Kneeland, for 25 years with United Engineering & Foundry Company, Pittsburgh, in the roll sales department has been appointed manager of roll sales of the Youngstown Foundry & Machine Company, Youngstown, Ohio.

* * *

James K. Payne, formerly manager of the brick department, Hydraulic Press Brick Company, St. Louis, has opened offices in that city where he will engage in the manufacture and sale of refractories.

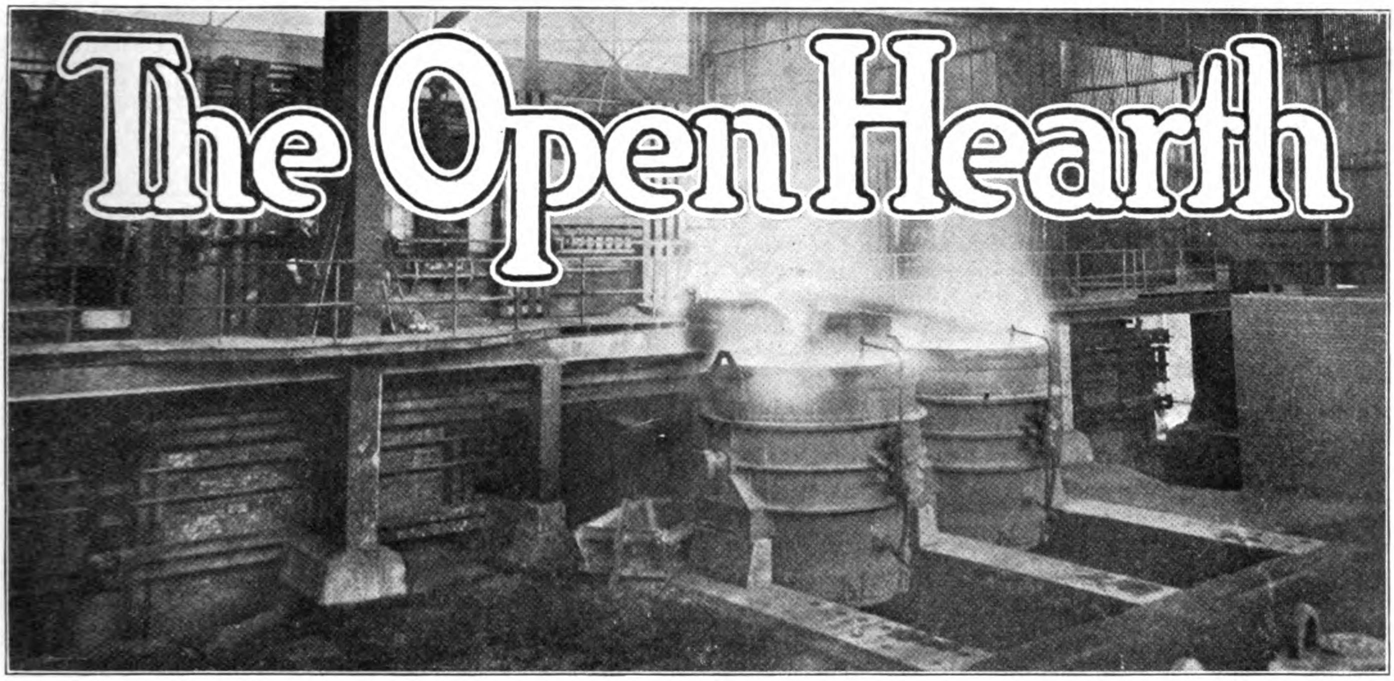
* * *

John W. McMahon, for five years, superintendent of the cold rolling department of the Superior Steel Corporation, Pittsburgh, has been made special represetative of the corporation. Mr. McMahon has been identified with the company for 22 years, in the capacity of roller, department foreman, assistant superintendent and superintendent of the cold rolling departments.

* * *

J. E. Montgomery, for some years general manager of the Whitaker works at Wheeling, W. Va., the Beech Bottom works at Beech Bottom, Brooke County, W. Va., and the Martins Ferry works, Martins Ferry, Ohio, of the Wheeling Steel Corporation, Wheeling, has been made vice president of the company. He succeeds George W. Moore. Mr. Montgomery's advancement comes after an affililation of 13 years with the Wheeling Steel Corporation. For 12 years he was with the United States Steel Corporation. Mr. Moore, after a service of 17 years, has resigned as vice president, due to ill health. J. H. Spel-

The Open Hearth



lacy has been appointed to succeed E. H. Collester as general superintendent of the Steubenville works.

* * *

Paul E. Good, manager of the centrifugal blower and compressor department of the Elliott Company of Jeannette, Pa., has moved his office from the Woolworth Building to 140 Cedar Street.

* * *

Mr. Frank R. Meyer, Jr., has been appointed assistant vice president of the Inland Steel Company in charge of sheet steel sales. He succeeds Mr. Walter C. Carroll, vice president, who recently resigned to assume the position of president of the National Association of Sheet and Tin Plate Manufacturers. He will be succeeded in St. Louis by Mr. Walter F. Brumm, who has been associated with the Inland Steel Company in its Kansas City and St. Louis offices for several years. Prior to his connection with the Inland Steel Company, Mr. Brumm was employed by the National Enameling & Stamping Company, the Midvale Steel & Ordnance Company, and other steel companies.

* * *

Mr. Charles A. Perryman, former sales manager of the wire rope department of the Wickwire Spencer Steel Company, Inc., is now associated with the American Cable Company, in the capacity of assistant sales manager. Mr. Perryman will make his headquarters at 105 Hudson Street, New York City.

* * *

Dr. Robert J. Piersol, who has been associated with Westinghouse Electric & Mfg. Company as a research engineer during the last four years, has changed to consulting engineering, specializing on the installation and operation of chromium plating. His mailing address will now be 3617 Dawson Street, Pittsburgh.

* * *

C. E. Skinner, Sc.D., assistant director of engineering, and Mr. W. Bradshaw, of the supply sales department, Westinghouse Electric & Mfg. Company sailed August 17, on the Steamer George Washington, as delegates to the International Electrotechnical Commission Convention, which will be held at Bellagio, on Lake Como, Italy, September 4 to 24.

Dr. Skinner is chairman of the Delegation of Standard Voltages, Chairman of the Delegation on Traction Motors, and is the U. S. Representative of the Committee of Seven Nations of the proposed International Standards Association. Mr. Bradshaw is official U. S. Delegate on watthour meters.

* * *

Frank R. Meyer, Jr., succeeds Walter C. Carroll as assistant vice president in charge of sheet steel sales of the Inland Steel Company, Chicago. Mr. Meyer formerly was sales manager of the Inland Steel Company's St. Louis office, a position which he has held since January, 1919. He began his business career with the Standard Stamping Company, which he left after 16 years of service. Walter F. Brumm follows Mr. Meyer as district sales manager in St. Louis. He has been connected with the Inland Steel Company's Kansas City and St. Louis offices for several years.

* * *

Harry C. Crawford, formerly of Pittsburgh, has been appointed traffic manager for the Bethlehem Steel Corporation with headquarters at Bethlehem, Pa.

Until a few years ago Mr. Crawford was assistant traffic manager of the Carnegie Steel Company here. He left to become traffic manager for the Cambria Steel Company, Philadelphia, and later entered the Bethlehem organization when Cambria was acquired by the Bethlehem.

* * *

Mr. E. H. Schmitz has been made district manager of the Pittsburgh office of the Riley Stoker Corporation.

Mr. Schmitz, after graduating from the Massachusetts Tech, was in the employ of the Sinclair Oil Company, being affiliated with their combustion engineering department at Houston, Texas. He then entered the employ of the Tennant Company, consulting engineers, in Houston, specializing in power plant work.

He has been with the Riley Stoker Corporation since 1925, devoting his time to experimental developments and tests.

TRADE PUBLICATIONS

Recording Ammeters is the title of an attractive catalogue—No. 1502—now being mailed by The Bristol Company of Waterbury, Conn. The catalogue, which is well illustrated, besides describing the many different models explains their operation and application to equipment such as transformers, motors, electric furnaces, ovens, etc. Means are provided, on these ammeters, for connecting signaling devices which give a warning when maximum or minimum conditions are reached on the equipment to which the ammeters are attached. The recording type is particularly featured.

* * *

"Tests of the Fatigue Strength of Cast Iron" is well covered in Bulletin No. 164 published June 7, by the University of Illinois. The university was assisted in conducting the tests by the Allis-Chalmers Manufacturing Company. The object of the tests was to determine the capacity of gray iron to resist repeated stress. Illustrations which show the equipment employed in working the tests are accompanied by micrographs of the metal. The booklet contains 50 pages.

* * *

General Electric turbines are described in two leaflets distributed from Schenectady. These leaflets are numbered GEA-598 and GEA-578A. In the former the general principles of operation and the construction of turbines are briefly explained while the latter is devoted to type D, mechanical drive turbines.

* * *

Elliott blowers and compressors which are attractively described in Bulletin P just issued by the Elliott Company are a continuation of the work of the Rateau-Battu-Smoot Company of New York City, whose blower and compressor business has been purchased by Elliott Company. These blowers for some years have been manufactured in the plant of the former Ridgway Dynamo and Engine Company, Ridgway, Pa., also purchased by Elliott Company.

The bulletin gives a very complete showing and description of these blowers, the distinctive features of which are the use of high speeds, an open radial impeller, and the attaining of maximum capacity and efficiency in compact size. The bulletin, in addition to a complete description of the construction of these blowers, gives valuable technical information and curves for figuring blower sizes and capacities.

A copy will be sent to anyone interested upon application to Elliott Company, General Sales Office, Jeannette, Pa.

COMING MEETINGS

Sept. 15—American Refractories Institute at the Clifton Hotel, Niagara Falls, Canada. Headquarters, 2202 Oliver Building, Pittsburgh, Pa.

* * *

Sept. 12-17—International Congress for Testing Materials. Meeting at Amsterdam, Holland. Headquarters at Valckenierstraat 2, Amsterdam, Holland.

Sept. 19-22—Society of Automotive Engineers. Production meeting at Hotel Winton, Cleveland, Sept. 19-20 and Hotel Statler, Detroit, Sept. 21-22. Coker F. Clarkson, secretary, 29 West Thirty-ninth Street, New York.

* * *

Sept. 19-22—American Welding Society. Fall meeting at Book-Cadillac Hotel, Detroit. M. M. Kelly, secretary, 33 West Thirty-ninth Street, New York.

* * *

Sept. 19-22—Institute of Metals. Meeting at Book-Cadillac Hotel, Detroit. H. Foster Bain, secretary, 29 West Thirty-ninth Street, New York.

* * *

Sept. 19-23—Associated Machine Tool Dealers. Meeting at Hotel Hollenden, Cleveland. T. W. Carlisle, secretary, 1392 West Third Street, Cleveland.

* * *

Sept. 19-23—American Society for Steel Treating. Ninth annual convention at Hotel Statler, Detroit. National steel and machine tool exposition at Convention Hall. W. H. Eisenman secretary, 4600 Prospect Avenue, Cleveland.

* * *

Sept. 19-23—National Machine Tool Builders' Association. Exposition of machine tools at Public Hall, Cleveland. E. F. DuBrul, 630 Vine Street, Cincinnati, is general manager. Robert Everett, manager, Room 620, 225 West Thirty-fourth Street, New York.

* * *

Sept. 20-23—Iron and Steel Institute. Autumn meeting at Royal Technical College, Glasgow, Scotland. G. C. Lloyd, secretary, 28, Victoria Street, London, S. W. 1.

* * *

Sept. 26-30—National Safety Council. Annual congress at Hotel Stevens, Chicago. W. H. Cameron, managing director, 108 East Ohio Street, Chicago.

* * *

Oct. 10-13—First National Fuels Meeting, Fuels Division A. S. M. E., St. Louis, Mo., Edwin C. Moody, chairman, 1932 N. Broadway, St. Louis.

* * *

October 10-13—American Society of Mechanical Engineers, First National Fuels Meeting. St. Louis. Victor J. Azbe, chairman, 6625 Delmar Boulevard, St. Louis, Mo.

* * *

Oct. 25-29—American Institute of Steel Construction. Fifth annual convention, Pinehurst, N. C. Charles F. Abbott, executive director, 285 Madison Avenue, New York, N. Y.

Welding Conference

A conference embracing all phases of the welding industry is to be held at the University of Minnesota on October 20, 21, 22, 1927, according to plans worked out by Professor S. C. Shipley, acting head of the Mechanical Engineering Department of the College of Engineering. This is the first conference of this nature held by the University of Minnesota, but according to the considerable interest shown by the users of welding equipment in the territory, the holding of such a conference promises to be a yearly event.

THE STEEL PLANT BRICK MASON

A Section Devoted to Items of General Interest to Blast Furnace and Steel Plant Brick Masons

Furnace Wall Insulation

"Heat Insulation in the Iron and Steel Plant," Bulletin 107, published by the Celite Products Company, contains a description of the manner of insulating all types of furnaces, stoves, gas producers and boilers. Illustrations make clear the application of the insulating material to the various sections of the furnaces. The bulletin will undoubtedly prove of interest to all those concerned with the design, or operation of furnaces.

J. H. Ellis is superintendent of masons at the Scullin Steel Company of St. Louis. This plant, besides operating 11 30-ton O. H. furnaces, has many heating furnaces, consequently Mr. Ellis has a real job.

Plastic Refractories

Plastic Refractories is the subject of Technologic Paper No. 3 issued by the American Refractories Institute. As the name implies the paper presents information on the use of those refractories applied in the plastic state. Tests were conducted to determine the drying and firing properties, amount of spalling, etc., of various makes. The Ideal Plastic Clay is described as one that is highly plastic with a good body, has the lowest drying shrinkage, high green strength, P. C. E. above 30, low firing shrinkage and of an open burning nature and long firing range.

Terms Relating to Refractories*

Plastic or Bond Fire Clay—A fire clay of sufficient natural plasticity to bond non-plastic materials.

Flint Fire Clay—A hard or flint-like fire clay occurring as an unstratified massive rock, practically devoid of natural plasticity and breaking with a concoidal fracture.

Diaspore Clay—A rock consisting essentially of diaspore bonded by fire clay.

Nodular Fire Clay—A rock containing aluminous and/or ferruginous nodules bonded by fire clay.

Note—In some districts such clays are called "burley" or "burley flint" clay.

Spalling—Breaking or cracking of refractories to such an extent that fragments are separated, presenting newly exposed surfaces of the residual mass.

Note—The causes of spalling may be classified under three main headings: namely, thermal mechanical and structural, as follows:

Thermal:

(*a*) *Factors Related to Service*—Rapidity and range of thermal fluctuation; contamination by slags and fluxes; tightness of joints; previous vitrification.

(*b*) *Factors Related to Refractories*—Degree and uniformity of reversible thermal expansion; heat transfer. elasticity; plastic flow.

Mechanical:

(*a*) *Factors Related to Service*—Rapid heating of wet brick; abuse in removing clinker and slag; unequal and excessive stresses; pinching; no provision for expansion; thin joints.

(*b*) *Factors Related to Refractories* — Mechanical strength; toughness; accuracy of shape.

Structural:

(*a*) *Factors Related to Service*—Slags and fluxes; character of the material in joints; insulation of refractories.

(*b*) *Factors Related to Refractories* — Vitrification; shrinkage; nature of bond; structure; degree of burning.

Pyrometric Cone Equivalent—An index to the degree of fusion resulting in a cone of the material bending until the tip touches the plaque as a result of a definite heat treatment, in accordance with the Standard Method of Test for Softening Point of Fire-Clay Brick (Serial Designation: C 24) of the American Society for Testing Materials.†

Note — The terms "fusion point," "softening point," "deformation point," and "melting point" have heretofore been loosely used for "pyrometric cone equivalent."

Tentative Specifications for Clay Fire Brick for Stationary Boiler Service‡

In these specifications brick are divided into siliceous and non-siliceous grades, but no other definite requirement is stipulated as to analysis, as no definite relationship between analysis and service has been demonstrated. The softening point requirements are well above the temperatures actually attained by the brickwork in general boiler practice.

The most important causes of failure are spalling and slag action. The spalling test specified will select brick of satisfactory resistance to thermal shock for general boiler practice. In those installations where exceptionally severe spalling seems to occur, the failure

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*A.S.T.M. Serial Designation C-27T.

†1924 Book of A.S.T.M. Standards.

‡American Society for Testing Materials.

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of the brick may in many cases be the result of factors which cannot be measured in the spalling test. Such conditions call for study by a competent engineer.

Brick which are subjected to severe slagging conditions in service should not be required to meet a severe spalling test requirement. Although slagging is one of the major causes of failure of the refractories, no test for slag resistance is included in these specifications for the reason that in the light of present knowledge none of the methods of making slag tests that have been proposed can be regarded as satisfactory.

Revision of the requirements is to be expected as methods of testing are further perfected, and as the effect of operating conditions upon the life of the brick becomes better understood. However, clay fire brick which fail to meet the requirements of these specifications may be regarded as unsatisfactory for general boiler service.

1. These specifications are intended to cover only burned products made from fire clay by the usual processes of manufacture and containing not more than 55 per cent alumina or 85 per cent silica. Even within this range of composition, it is not intended to include products other than those regularly sold as clay fire brick.

Size Tolerance

2. Variation (plus or minus) of 2 per cent from specified dimensions covering both shrinkage and warpage shall be allowed on dimensions of 4 in. or over. On dimensions under 4 in., 3 per cent variation shall be allowed.

Moderate Heat Duty Boiler Settings

3. The requirements for brick for moderate high duty boiler settings are intended to apply to boiler furnaces in which the temperatures are not over 2,400 deg. F. (1,315 deg. C.).

A. Zone of Highest Temperatures (sidewalls, arches, doors, and jambs):

4. (*a*) *Softening Point*—The softening point shall not be below cone 29 in the case of the non-siliceous and not below cone 27 in the case of the siliceous grade.*

(*b*) *Linear Change*—When duplicate samples are heated uniformly to a temperature of 1,350 deg. C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of more than 1.5 per cent of the original length.

B. Zone of Lower Temperatures (backing-up brick for highest temperature zone, and walls beyond first tube bank):

5. (*a*) *Softening Point*—The softening point shall not be below cone 18.

(*b*) *Modulus of Rupture*—The modulus of rupture of the brick tested cold shall not be under 500 lb. per sq. in.

High Heat Duty Boiler Settings

A. Zone of Highest Temperatures (sidewalls, bridgewalls, arches, doors and jambs; and first pass sidewalls):

6. The requirements for brick for zone of highest temperatures in high duty boiler settings are intended to apply to boiler furnaces in which the temperature of the combustion chamber is continuously, or a significant portion of the time, above 2,400 deg. F. (1,315 deg. C.) under normal conditions of operation. The refractoriness of the non-siliceous grade is assured by the softening point, but for this requirement in the case of the siliceous grade it is necessary to incorporate both the softening point and load test.

7. (*a*) *Softening Point*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change*—When duplicate samples are heated uniformly to a temperature of 1,400 deg. C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 1.5 per cent in the case of the non-siliceous grade and 0.75 per cent in the case of the siliceous grade.

(*c*) *Spalling*—When subjected to the spalling test, brick shall withstand an average of five dips in the case of the non-siliceous grade and three dips in the case of the siliceous grade.

(*d*) *Deformation*—Deformation in the standard load test at 1,350 deg. C. under a load of 25 lb. per sq. in. shall not be over 6 per cent in the case of the siliceous grade.

8. *Service Condition No.* 1—For division walls heated on both sides, the following requirements shall apply:

(*a*) *Softening Point*—The softening point shall not be below cone 31 in the case of the non- siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Deformation*—Deformation in the standard load test at 1,350 deg. C. under a load of 25 lb. per sq. in. shall not be over 6 per cent in the case of the non-siliceous grade and not over 4 per cent in case of the siliceous grade.

Note—It is not practical to include a spalling test for brick subject to rigid load test requirements.

9. *Service Condition No.* 2.—Under severe conditions of spalling, the following requirements shall apply:

(*a*) *Softening Point*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change*—When duplicate samples are heated uniformly to a temperature of 1,400 deg. C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 2 per cent in the case of the non-siliceous grade and 1 per cent in the case of the siliceous grade.

(*c*) *Spalling*—When subjected to the spalling test, brick shall withstand an average of nine dips in the case of the non-siliceous grade and four dips in the case of the siliceous grade.

Note—It is not practical to include a limit for deformation under load, since fire-clay brick which are so made as to give the highest resistance to spalling are relatively weak under load.

10. *Service Condition No.* 3—For service where slagging conditions are severe, the following requirements shall apply:

(*a*) *Softening Point*—The softening point shall not be below cone 31 in the case of the non-siliceous grade and not below cone 28 in the case of the siliceous grade.

(*b*) *Linear Change*—When duplicate samples are heated uniformly to a temperature of 1,400 deg. C., maintained at this temperature for 5 hours and cooled, they shall not show an average contraction of the original length of more than 1 per cent in the case of the non-siliceous grade and 0.5 per cent in the case of the siliceous grade

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*Brick are considered as being of siliceous grade when the silica content is greater than 65 per cent and of non-siliceous grade when the silica content is 65 per cent or less

SAFETY FIRST IN THE STEEL PLANT

Section Devoted to the Interest of the Safety Movement

Steel Men to Address Convention

Although the sixteenth annual Safety Congress will not open until September 26, practically all of the principal speakers have been secured and the program is rapidly being perfected.

Dr. Lucian W. Chaney, of the U. S. Bureau of Labor Statistics, will present "A Record of Progress in the Metal Industries" at the sixteenth annual safety congress at Chicago on Tuesday morning, September 27, when the members of the Metals Section of the National Safety Congress hold their special meeting. Charles R. Hook, vice president American Rolling Mill Company, will talk about "Safety in American Industry." On Wednesday morning, September 28, Al. Jaco, of the Commonwealth Steel Company will discuss "Safety as a Foreman Sees It" and L. D. Underwood, of the Youngstown Sheet & Tube Company, will dwell on "Safe Practices at the Blast Furnace." C. L. Peake, of the American Radiator Company will tell of "Common Hazards in Foundries" and Geo. P. Wardley of the Illinois Steel Company will speak on "Coke Plant Accidents and Their Elimination." On Thursday morning, N. V. B. Ziegler, of the U. S. Aluminum Company, will tell about "Conducting a Safety Meeting" and a lantern slide address will be delivered by John A. Oartel of the Carnegie Steel Company.

All of the meetings will be held in the new Stevens Hotel, Chicago, where for the first time in several years it will be possible to house all of the sessions, luncheons, dinners, exhibits, etc., under one roof.

"The Straight Thinking Man Respects Safety" is the inscription on the base of the Bronze Safety Trophy presented by The American Rolling Mill Company, Middletown, Ohio, to the champion department in its annual safety contest. The trophy is a statue of an iron worker by the well known sculptor, Clement J. Barnhorn of Cincinnati, Ohio.

No Lost Time Accident in June

In June eight plants of the American Sheet & Tin Plate Company, employing 4,364 persons, operated without a single lost-time accident. These plants included the Cambridge works, Cambridge, Ohio; Chester works, Chester, W. Va.; La Belle works, Wheeling, W. Va.; Leechburg works, Leechburg, Pa.; Mercer works, Farrell, Pa.; roll and machine works, Canton, Ohio; Wood works, McKeesport, Pa. and American works, Elwood, Ind.

Eight other works, employing 8,011 persons had only one lost-time accident for each plant, in the same month.

Steel Industry Sickness Lower than Public Utilities

There was considerably more sickness reported among men employed in public utilities than in iron and steel manufacturing, and in a group of miscellaneous industries; and the frequency of certain diseases varied considerably according to industry. In iron and steel manufacturing there were relatively few diseases of the nervous system reported, and the average rate for bronchitis and for influenza and grippe was low. On the other hand, a higher rate was found for certain epidemic and infectious diseases such as smallpox, typhoid fever, and malaria, and the pneumonia rate among iron and steel workers was well above its frequency in the other industries included in the study.

—U. S. Public Health Service Report.

The Business Facts of Safety

After a thorough investigation a large insurance company says that for every dollar paid out in compensation, $4 goes for lost time, labor turnover, waste materials, etc.

Accident costs, including insurance, medical expense, material spoilage, and all other direct or indirect expenses, are simply added to the cost of finished goods.

Are you sure you are not paying more than necessary—are you sure that your competitors are not getting business you should have, because they have discovered the way to reduce or eliminate accidents and therefore can normally undersell?

—National Safety Council.

The Spirit of Safety

And the end is that the workman shall live to enjoy the fruits of his labor; that his wife shall not be untimely a widow; and that his children shall have a father.

P. B. Juhnke.

The Blast Furnace and Steel Plant

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